MODERNISING SCIENTIFIC CAREERS

Scientist Training Programme

MSc in CLINICAL SCIENCE

Curriculum

CARDIAC, CRITICAL CARE, VASCULAR, RESPIRATORY AND SLEEP SCIENCES

2013/14
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READERSHIP

This Scientist Training Programme (STP) MSc Clinical Science curriculum describes the MSc Clinical Science programmes that, together with the work based learning guide, provide the details of each themed STP in the UK for:

- academic and administrative staff, including external examiners within Higher Education Institutions (HEIs);
- trainees, host departments and managers of services that employ healthcare science staff;
- work based trainers, including all those involved in supervising, mentoring, coordinating, assessing and delivering STP education and training;
- Local Education and Training Boards (LETBs) and all healthcare science education and training commissioning organisations in the UK;
- patients and the public;
- Modernising Scientific Careers (MSC) accreditation panels.

A glossary of terms used is provided in the Appendices.
Section 1: Introduction to Modernising Scientific Careers (MSC) and the Scientist Training Programme (STP)

1.1 Introduction to Modernising Scientific Careers (MSC)

1. The healthcare science (HCS) workforce plays a central role in safe and effective patient care across all pathways of care from health and wellbeing to end of life. There are approximately 55,000 employees in the healthcare science workforce in the NHS in the UK, and approximately 80% of all diagnoses can be attributed to their work.

2. Healthcare science involves the application of science, technology and engineering to health. Good Scientific Practice (GSP) [Appendix 3] sets out the principles and values on which good practice within healthcare science is founded. It makes explicit the professional standards of behaviour and practice that must be achieved and maintained by all those who work in healthcare science. GSP and the Education and Training Standards of the Health and Care Professions Council (HCPC) together form the basis for all MSC training curricula which contextualise the Standards of Proficiency set down by the HCPC in a way that is accessible to the profession and the public.

3. The healthcare science workforce and services have traditionally been grouped into three broad areas called divisions, namely: Life Sciences/Clinical Laboratory Sciences, Physical Sciences/Medical Physics and Biomedical Engineering, and Physiological Sciences/Clinical Physiology Sciences. Within each division there are a number of healthcare science specialisms. With advances in scientific technology, changes to the delivery of healthcare scientific services and the development of MSC, the boundaries between these divisions have been shifting. MSC recognises this important change and to date has identified twelve STP themes within healthcare science, which enables training across a total of 28 healthcare science specialisms, with curricula for additional specialisms still under development.

1.2 Introduction to the Scientist Training Programme (STP)

4. The STP is designed to provide healthcare scientist trainees with strong science-based, patient-centred clinical training in a specialist area of healthcare science. Initial rotational training provides a broad base of knowledge, skills and experience across a group of related cognate specialisms reflective of the evolving clinical and scientific changes and requirements followed by specialisation in a single HCS specialism. STP is a three-year pre-registration postgraduate academic (MSc Clinical Science) and work based programme.

5. Recruitment to the programme is competitive, and in England a national recruitment process is led by the National School of Healthcare Science (NSHCS). Following induction, workplace training commences with a
rotational training programme in a themed group of up to four healthcare science specialisms, followed by training in a specific specialism.

6. The STP is an integrated training programme combining academic study leading to the award of a specifically commissioned MSc in Clinical Science and a work based training programme. Completion of both will lead to the award of a Certificate of Completion of the Scientist Training Programme (CCSTP) by the NSHCS. Graduates are eligible to apply to the Academy for Healthcare Science for a Certificate of Attainment and will then be eligible to apply to HCPC for registration as a Clinical Scientist.

1.3 Scientist Training Programme Outcomes: 2013/14

Graduates of the STP will possess the essential knowledge, skills, experience and attributes required of a newly qualified Clinical Scientist. STP graduates will have clinical and specialist expertise in a specific healthcare science specialism, underpinned by broader knowledge and experience within a healthcare science division or theme. They will be competent to undertake complex scientific and clinical roles, defining and choosing investigative and clinical options, and making key judgements about complex facts and clinical situations within a quality assurance framework. Many will work directly with patients and all will have an impact on patient care and outcomes. They will be involved, often in lead roles, in innovation and improvement, research and development, and/or education and training.

On completion of the STP all graduates should be able to demonstrate the following.

Professional Practice

1. Professional practice that meets the professional standards of conduct, performance and ethics defined by Good Scientific Practice and the regulator (HCPC), and is safe, lawful and effective, and within the scope of practice for the role undertaken, while maintaining fitness to practise.
2. Personal qualities that encompass communication skills, self-management, self-awareness, acting with integrity and the ability to take responsibility for self-directed learning, maintaining their own health and wellbeing, critical reflection and action planning to maintain and improve performance.
3. The ability to be an independent self-directed learner acting autonomously in a non-discriminatory manner when planning and implementing tasks at a professional level, contributing to the education and training of colleagues and providing mentoring, supervision and support as appropriate.
4. The ability to work, where appropriate, in partnership with other professionals, often as part of a multidisciplinary team, supporting staff, service users and their relatives and carers while maintaining confidentiality.
5. The ability to work with public, service users, patients and their carers as partners in their care, embracing and valuing diversity.
Scientific and Clinical Practice

6. A systematic understanding of relevant knowledge, and a critical awareness of current problems, future developments and innovation in health and healthcare science practice, much of which is at, or informed by, the forefront of their professional practice in a healthcare environment.

7. High-quality clinical and scientific practice that applies basic, core scientific knowledge, skills and experience in a healthcare setting, places the patient and the public at the centre of care, prioritising patient safety and dignity and reflecting NHS/health service values and the NHS Constitution.

8. The ability to perform quality assured appropriate diagnostic or monitoring procedures, treatment, therapy or other actions safely and skilfully, adhering to applicable legislation and in compliance with local, national and international guidelines.

9. The ability to deal with complex scientific and clinical issues both systematically and creatively, make sound judgements in the absence of complete data, and communicate their conclusions clearly to specialist and non-specialist audiences, including patients and the public.

10. The ability to define and choose investigative and scientific and/or clinical options, and make key judgements about complex facts in a range of situations.

11. Originality in the application of knowledge, together with a practical understanding of how established techniques of research and enquiry are used to create and interpret knowledge in healthcare and healthcare science and their specialism.

Research, Development and Innovation

12. A comprehensive understanding of the strengths, weaknesses and opportunities for further development of healthcare and healthcare science as applicable to their own clinical practice, research, audit, innovation and service development, which either directly or indirectly leads to improvements in patient experience, clinical outcomes and scientific practice.

13. Conceptual understanding and advanced scholarship in their specialism, enabling them to critically evaluate and critique current research and innovation methodologies and, where appropriate, propose new research questions and hypotheses.

Clinical Leadership

14. Scientific and clinical leadership based on the continual advancement of their knowledge, skills and understanding through the independent learning required for continuing professional development.

15. The ability to critique, analyse and solve problems, define and choose investigative and scientific and/or clinical options, and make key judgements about complex facts in a range of situations.
1.4 Overview of the MSc Clinical Science Programme

7. This document sets out the proposed structure, high-level learning outcomes and indicative content for the proposed three-year, part-time Masters in Clinical Sciences that forms part of the Scientist Training Programme (STP). The programme combines and integrates the generic professional practice learning, themed learning in a group of specialisms and individual specialist programmes.

8. Figure 1 depicts the overall structure and timing of each STP programme while Figure 2 depicts the broad framework around which all MSc Clinical Science programmes must be structured. However, each division within the Modernising Scientific Careers Programme (MSC) has interpreted and adapted this framework.

Figure 1: Modernising Scientific Careers: Scientist Training Programme (STP): Diagrammatic representation of employment-based, pre-registration, three-year NHS-commissioned education and training programme
**Figure 2: High-Level Framework for MSc Clinical Science**

<table>
<thead>
<tr>
<th>Year 3 Specialist Practice</th>
<th>Healthcare Science</th>
<th>Research Project</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Specialist Learning with integrated Professional Practice</td>
<td>Students would usually begin a work based research project in Year 2 and complete the project in Year 3</td>
</tr>
</tbody>
</table>

**Specialism**

<table>
<thead>
<tr>
<th>Year 2 Specialist Practice</th>
<th>Research Methods</th>
<th>Healthcare Science</th>
<th>Research Project</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[10]</td>
<td>Specialist Learning with integrated Professional Practice</td>
<td>Students would usually begin a work based research project in Year 2 and complete the project in Year 3</td>
</tr>
</tbody>
</table>

**Generic**

<table>
<thead>
<tr>
<th>Year 1 Core Modules</th>
<th>Healthcare Science</th>
<th>Healthcare Science</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Integrating science and Professional Practice</td>
<td>Integrating underpinning knowledge required for each rotational element with Professional Practice</td>
</tr>
</tbody>
</table>

**Division/Theme**

- **Generic Modules:** Common to all divisions of healthcare science
- **Division/Theme-Specific Modules:** Common to a division or theme
- **Specialist Modules:** Specific to a specialism
Section 2: Entry Routes, Award Title, Delivery, Accreditation of Prior Learning

2.1 Entry Routes

9. In England there are two routes of entry into STP. Through the direct entry route, the trainee will be competitively appointed. Alternatively, some STP trainees may enter into training with support of their employers through an in-service training route, as long as employers can demonstrate the ability to support STP training by meeting work based accreditation standards. In both cases potential STP applicants must participate in the national recruitment/assessment process and meet the minimum entry requirements for the academic and work based programme. For direct entry applicants, this will be a competitive process, whereas in-service trainees will be required to go through the national recruitment process to ensure that they meet the standards for entry into STP.

2.2 Progression

10. No condonement/compensation of modules and no aggregation of marks are permitted. Students must pass all modules to be eligible for the final award.

2.3 Award Titles

11. The title of the degree programme should be consistent with current MSC terminology. The award titles are:

Life Sciences
MSc Clinical Science (Blood Sciences)
MSc Clinical Science (Cellular Sciences)
MSc Clinical Science (Genetics)
MSc Clinical Science (Infection Sciences)

Physical Sciences and Biomedical Engineering
MSc Clinical Science (Medical Physics)
MSc Clinical Science (Clinical Engineering)
MSc Clinical Science (Reconstructive Science)
MSc Clinical Science (Clinical Pharmaceutical Science)

Physiological Sciences
MSc Clinical Science (Cardiac, Critical Care, Vascular, Respiratory and Sleep Sciences)
MSc Clinical Science (Gastrointestinal Physiology and Urodynamic Science)
MSc Clinical Science (Neurosensory Sciences)

Across all Divisions
MSc Clinical Science (Clinical Bioinformatics)
In accordance with their own discretion and regulations, HEIs may be able to seek a variation in the award title to enable the specialism to be identified. This should be raised as part of MSC Accreditation and discussed with the commissioner.

2.4 **Mode of Delivery:** Part-time

2.5 **Relevant Quality Assurance Agency (QAA) Code(s) of Practice**

12. HEIs should adhere to the current QAA Code of Practice for the Assurance of Academic Quality and Standards in Higher Education. At the time of preparing this document the QAA is in the final stages of a major review of the Code of Practice and is expected to publish ‘The UK Quality Code for Higher Education’. Further details can be found on the QAA website: [http://www.qaa.ac.uk/Pages/default.aspx](http://www.qaa.ac.uk/Pages/default.aspx)

2.6 **Awarding Body**

13. While the full programme could be delivered and awarded by a single university provider, equally a collaborative partnership between a number of universities may be preferable. It would be expected that where collaborative provision is proposed a memorandum of agreement or understanding is in place. The delivery arrangements must be clearly defined, including the academic and logistical responsibilities of each partner and the financial arrangements between the university and its partner. The awarding university must satisfy itself that the partner is able to discharge its responsibilities satisfactorily and will be responsible for the quality assurance of the programme.

2.7 **Accreditation of Prior Learning**

14. A process for Accreditation of Prior Learning (APL) that conforms to the guidelines below must be defined by each HEI provider. This must clearly define the minimum and maximum level of APL that will be awarded, the timing, costs and process, and align to statutory requirements for healthcare science. Good practice supports the view that such prior learning should only be used once, double counting is not recommended.

*QAA ‘Higher education credit framework for England: guidance on academic credit arrangements in higher education in England’, August 2008*

*QAA ‘Guidelines on the accreditation of prior learning’, September 2004*
2.8 Programme Delivery and Monitoring

15. The tender and subsequent MSC accreditation process will require an HEI to provide a detailed description of the content of each module and the teaching and learning and assessment strategy to demonstrate how the programme and module aims/learning outcomes will be met.


HCPC ‘Standards of education and training’, September 2009
http://www.hpc-uk.org/aboutregistration/standards/sets/
Section 3: The MSc Clinical Science Curriculum

3.1 Purpose

16. The purpose of the STP MSc curriculum is to clearly set out the expectations of graduates from the programme, including the academic skills, knowledge and understanding that each trainee will be expected to gain, develop and apply during work based training. Set within an integrated academic and work based programme the expectations of all MSc programmes should be read alongside the work based learning guides.

Additionally, the purpose is to signal the importance of providers being aware of the current structure, strategic direction and priorities of healthcare delivery in the UK, for example the NHS Constitution. The requirement to prioritise patients and their care and ensure that the patient and service provided by healthcare science is at the centre of all learning, assessment and work based practice is equally important.

3.2 Curriculum Development and Maintenance

17. Curriculum development began in 2010 and has been led by the Modernising Scientific Careers (MSC) team working with NHS and higher education colleagues and patients. Since 2012 the NSHCS has also contributed to curriculum development and maintenance via the professional leads and each of the NSHCS themed boards. Professional bodies have been represented in some curriculum working groups and have also been invited to provide feedback as the work developed, either directly or via the NSHCS themed boards.

All programmes have also been reviewed and approved by Health Education England via the Healthcare Science Professional Board Education and Training Working Group. External feedback from a review undertaken in 2012 by the Institute of Education has been incorporated into all programmes from 2013 onwards. All of the latest versions of the MSc Clinical Science programmes and work based learning guides can be found on the NHS Networks website by following the link: http://www.networks.nhs.uk/nhs-networks/msc-framework-curricula

All MSC curricula will be subject to regular review, with all stakeholders given the opportunity to contribute to each review. This process is currently being set out in an MSC long-term curriculum maintenance plan.

18. STP MSc Clinical Science programmes leading to an academic award must be aligned to current NHS policy and strategy, and at the time of writing this guide should consider the recommendations of:

• Modernising Scientific Careers: The UK Way Forward (2010)
• Strategy for UK Life Sciences (December 2011)
• Strategy for UK Life Sciences One Year On (2012)
• Innovation Health and Wealth, Accelerating Adoption and Diffusion in the NHS (December 2011)
• NHS Commissioning Board planning guidance http://www.commissioningboard.nhs.uk/files/2012/12/everyonecounts-planning.pdf
• HEE Design to Delivery that will give you the statutory basis and duties of HEE http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/documents/digitalasset/dh_132087.pdf

HEIs should ensure they keep abreast of future strategic direction and policy.

3.3 Tender Process and Monitoring

19. Local Education and Training Boards are responsible for the commissioning of MSc Clinical Science programmes and the quality of each programme. The lead commissioner function for MSC programmes sits within the West Midlands.

3.4 MSC Accreditation

20. All MSc Clinical Science programmes must hold MSC Accreditation to confirm that commissioned MSc in Clinical Science programmes delivered by an HEI meet the requirements of the MSC Scientist Training Programme outlined in Modernising Scientific Careers: The UK Way Forward (DH, 2010). This accreditation process is currently the responsibility of the MSC Accreditation team, with advice given by the Health Education England Healthcare Science Professional Board (HEE HCSPB) and its Education and Training Working Group (HEE HCSPB ETWG).

3.5 Programme Delivery
21. HEIs are expected to ensure that all teaching, learning and assessment is up to date and informed by research to ensure that at graduation, Clinical Scientists meet the Framework for Higher Education Qualifications (FHEQ) descriptor at level 7 (http://www.qaa.ac.uk/). By undertaking a substantive research project bearing 60 credits, students should become aware of the major contribution the healthcare science workforce makes to research and innovation to benefit patients and the delivery of healthcare.

22. The key principles include:

- programmes must deliver the MSC learning outcomes and indicative content, which the HEE HCSPB Education and Training Working Group has advised meets the requirements of Modernising Scientific Careers: The UK Way Forward;
- wherever possible, delivery of the principles and knowledge underpinning practice should occur before the work based learning;
- programmes must meet current NHS education quality metrics and current Health and Care Professions Council (HCPC) Standards of Education and Training;
- the NSHCS, host departments, patients and the public should be involved in the design, implementation, delivery and review;
- assessment programmes must be fair, valid and reliable, and clearly articulated for all modules, and the timing and content should consider and complement the work based assessment programme;
- a robust student support and mentoring system must be in place and arrangements to support students in difficulty agreed with the NSHCS;
- a high-quality teaching and learning environment with appropriate resources and facilities to support teaching and research;
- teaching staff who are research active with a track record of undertaking high-quality research of national and international standing that is relevant to the practice of healthcare science and the NHS;
- evidence that each MSc programme meets the equivalent of the relevant HCPC Standards of Education and Training.

23. The Professional Practice and Good Scientific Practice underpin the MSc and work based programme. Key professional practice learning outcomes are included in the MSc programme and it is important that the MSc programme embeds the standards of professionalism set out in Good Scientific Practice in all aspects of the delivery and assessment of the programme. Trainees should be encouraged to develop a range of skills to support their professional life, and continuing professional development spanning communication, leadership, personal reflection, duty of care, duty of candour, critical
reflection, giving and receiving feedback, career planning, commitment to lifelong learning.

HEIs should ensure that all staff involved in each MSc programme have read and are aware of the requirements of Good Scientific Practice, a copy of which can be found in the Appendices.

3.6 Academic Induction

24. It is expected that there will be a period of academic induction at the start of each MSc programme.

3.7 Teaching and Learning

25. It is expected that a blended learning approach will be adopted, based on a model of student-centred adult learning that balances and integrates face-to-face teaching, e-learning, etc., and considers the broader requirements of each STP. It is expected that a broad range of teaching and learning activities will be utilised, appropriate to the learning outcomes. Trainees should be enabled to gain the skills necessary to manage their own learning, and to exercise initiative and personal and professional responsibility. The learning strategy matrix and proformas outlined in ‘Liberating Learning’ describe a range of activities that may be appropriate to this MSc programme; they are likely to include:

- Advanced library study
- Case study/discussions
- Debate
- Discussion forum
- Expert briefings
- Individual tutoring
- Interactive lectures
- Personal critical reflection and action planning
- Problem-based learning
- Role play
- Student-led and tutor-led seminars
- Skills teaching
- Simulation
- Self-assessment
- Self-directed learning activities
- Team projects
- Tutor-led small group learning

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26. It is also expected that e-learning and m-learning\(^2\) opportunities will be available to enable students to be active participants in a range of learning activities. Work based learning will also contribute to the academic educational experience of the trainees, for example seminars, journal clubs, local, national and international scientific and education meetings.

All contributors to the MSc should have up-to-date knowledge of the requirements of the programme, current healthcare science and education practice.

\(^2\) JISC TechDis: see [http://www.jisctechdis.ac.uk/technologymatters/mobilelearning](http://www.jisctechdis.ac.uk/technologymatters/mobilelearning) for further information with respect to mobile (m) learning.
3.8 **Interprofessional Learning**

27. Opportunities to enable interprofessional and interdisciplinary learning, within and outside healthcare science, should be a fundamental part of each programme.

3.9 **Patient and Public Involvement**

28. The HEI programme team should have mechanisms in place to ensure that there is meaningful patient and public involvement in the design, delivery, development and quality assurance of each programme. It is expected that patients will be represented on course committees at all levels and contribute to teaching, learning and assessment.

Descriptions of MSc programmes need to make clear and explicit links to new models of service delivery, care and patient pathways. The delivery of high-quality, compassionate, patient-centred care should be an integral part of each degree programme, with the emphasis on the contribution of the healthcare science workforce to ensure trainees are aware that their actions have an impact on the patient and the patient’s family. The responsibility of all staff in the NHS to maximise quality and productivity and efficiency and to continually strive to improve services should be stressed. Equally important is the ability of graduates from the STP to communicate with the general public with respect to healthcare science, leading to a better educated public that is encouraged to take responsibility for its own health and wellbeing and has a greater understanding of the role that science plays in society.
Section 4: Assessment

4.1 Purpose of Assessment

29. The purpose of assessment is to enable the trainee to demonstrate that they have the requisite knowledge, skills, attitudes and beliefs to work as a Clinical Scientist and, together with the successful graduation from the work based element of the STP, that they meet the HCPC standards of education and training, professional skills, conduct performance and ethics to provide reassurance to the public.

30. The MSc Clinical Science assessment programme should support assessment for learning, and in particular:

   • help clarify what good performance is (goals, criteria, standards);
   • encourage ‘time and effort’ on challenging learning tasks;
   • deliver high-quality feedback information that helps learners to self-correct;
   • encourage positive motivational beliefs and self-esteem;
   • encourage interaction and dialogue around learning (peer and teacher–student);
   • facilitate the development of self-assessment and reflection in learning;
   • involve students in decision making about assessment policy and practice;
   • support the development of learning communities;
   • integrate and complement the work based assessment programme;
   • help teachers adapt teaching to student needs.

31. The HEI must have in place a clear, overarching strategic and systematic approach to assessment that fits with the curriculum and delivers assessment methods that are valid, reliable/generalisable, feasible, fair, acceptable and defensible, and is led by assessment experts. The approach to the assessment of the MSc Clinical Science should also be cognisant of and complement the work based assessment programme.

32. The assessment programme should be designed to enable the trainee to obtain regular constructive feedback on progress and achievement. It should encourage critical reflection and action planning, identifying both strengths and areas for development and improvement.

33. The approach to assessment should include and be overseen by a central coordinating leadership group or assessment-focused group who oversee, advise and scrutinise assessment across modules and

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3 Quality Assurance Agency Code of Practice.

years in order to build a consistent approach to assessment across the whole programme, involving module/programme leaders as appropriate. The overall assessment strategy should be documented in a clear and accessible manner with accountabilities clearly allocated. The strategy should also demonstrate how the approach is based on a sound understanding of the evidence base, academic literature and good practice in assessment.

4.2 Key areas that must be covered by the Assessment Strategy include:

- A clear statement of accountabilities, including the governance structure for assessment.
- The balance between formative and summative assessment.
- The assessment of each module, including the contribution of individual assessments and examinations within the module.
- Progression criteria.
- The range of valid, reliable and appropriate assessment techniques that will be utilised across the programme and for each module.
- The process for providing clear and timely information for students.
- How all examiners will be trained (including refresher training) and the guidelines that will be given.
- The mechanisms in place to ensure comparability of standards and to share good practice, including external examiners.
- How standard setting is undertaken.
- How student feedback will be given, including time lines.
- The arrangements for assessment of students with a disability.
- An assessment blueprint demonstrating the relationship between each assessment and the learning outcomes of the programme.
- Exemplar criteria and marking scheme, including critical reflective writing.
- The process of appointing external examiners.
- A defined role for external examiners that includes contributing to the review and development of assessment strategies and providing advice from an overarching perspective.
Section 5: Trainee Supervision, Support and Mentoring

34. The trainee supervision, support and mentoring systems will span the academic and work based elements of STP, and the relationship between the two systems must be clear to trainees, work based staff and HEI staff. The trainee supervision, support and mentoring system must be designed to encourage safe and effective practice, independent adult learning, appropriate professional conduct of the trainee and the safety of the patient. Those undertaking the role of supervisor or mentor must have relevant qualifications and experience and have undertaken appropriate and up-to-date training. The HEI will be expected to have an academic supervisory, support and mentoring scheme in place and to provide access to student support services.

**Academic supervisor(s):** Responsible, usually as part of a supervisory team, for guiding and assisting students during their period of academic study, including the research module.

**Work based education supervisor:** Responsible for monitoring, supporting and assessing the trainee on a day-to-day basis in their scientific, clinical and professional work and may take on the role of co-supervisor of the research project as part of the academic supervisory team.

5.1 **Fitness to Practise**

35. The HEI must have a clear policy with respect to Fitness to Practise, which must clearly articulate how staff and students are made aware of the policy and how the policy is implemented. Alongside this must be a clear policy on how student whistleblowers are supported. Breaches of professional practice and behaviour identified by the HEI or during HEI activities must be reported and investigated in accordance with this Fitness to Practise policy and accurate records maintained within the HEI. The NSCHCS should be informed of any issues with respect to fitness to practise and professional suitability.
Section 6: Progression, Annual Monitoring of Progress, Equality and Diversity, Curriculum Review and Updating

### 6.1 Progression

36. All trainees will usually be expected to complete the requirements for the MSc Clinical Science award within three years after initial registration (periods of suspension will not lead to an automatic extension of this period). This aligns with the duration of the STP and it is expected that successful STP graduates will be required to attain both an MSc in Clinical Science and certification of completion of STP work based training.

### 6.2 Annual Monitoring of Progress

37. The programme governance must include annual monitoring of progress that considers the outcome of the review of each module (including student and lay evaluation) and the handling and consideration of the external examiner’s report. This process should enable the programme leaders to identify and propose changes to the programme in response to feedback.

### 6.3 Equality and Diversity

38. All programmes should reference and be able to demonstrate evidence of adherence to the Disability Discrimination Act 1995 (DDA) which was extended to education in September 2002, following amendments introduced by the Special Educational Needs and Disability Act (SENDA) 2001. Additionally evidence should be demonstrated to show adherence to the Disability Discrimination Act (2005) which includes the Disability Equality Duty and the QAA Code of Practice on Students with Disabilities should be available. All degree programmes should also include evidence of adherence to the 2010 Equality Act and any superseding legislation with respect to equality.

As part of this commitment to equality staff should be committed to inspiring and supporting all those who work, train and provide training in healthcare science to operate in a fair, open and honest manner. The approach taken is a comprehensive one and reflects all areas of diversity, recognising the value of each individual. This means that no one is treated less favourably than anybody else on the grounds of ethnic origin, nationality, age, disability, gender, sexual orientation, race or religion. This reflects not only the letter but also the spirit of equality legislation, taking into account current equality legislation and good practice.

Key legislation includes:

- Race Relations Act 1976 and the Race Relations Amendment Act (RRAA) 2000
- Disability Discrimination Act 1995 and subsequent amendments
- Human Rights Act 1998
- Employment and Equality (Sexual Orientation) Regulations 2003
- Employment and Equality (Religion or Belief) Regulations 2003
- Gender Recognition Act 2004

6.4 Curriculum Review and Updating

39. The review and updating of the doctoral level academic award curriculum will be part of the long-term MSC curriculum maintenance programme currently being developed.

If you have any feedback with respect to this programme please contact:
msc.hee@nhs.net
Section 7: Relationships and Partnerships

7.1 National School of Healthcare Science

40. The NSHCS provides a national coordinating and oversight function to support trainees and host departments in the delivery of STP training. It is responsible for:

- national recruitment into STP, enabling a transparent and robust selection of the very best science graduates;
- providing national oversight of STP trainees throughout their training by managing and monitoring their progress through the Online Learning and Assessment Tool (OLAT), supporting trainees in difficulty as well as coordinating national structured assessments both during and at the end of STP training;
- evaluation of ongoing work based assessment outcomes through the OLAT, enabling the School to benchmark training programme delivery for early identification of programme issues that may need to be addressed and resolved, and reporting these as part of agreed MSC governance arrangements;
- liaising with each HEI’s MSc Clinical Science programme director to ensure the integration and coordination needed to deliver the academic and work based programmes that form the STP; liaising with MSC Strategic Health Authority (SHA) leads (and education and quality leads in the future arrangements) on local issues and problems and their resolution;
- working closely with workplace training departments and providing support as appropriate;
- organising national ‘Train the Trainer’ programmes to ensure common standards of delivery and content, and recommending ongoing training activities to support the continuing professional development of work based trainers.

41. Professional Leads in each of the scientific divisions within the NSHCS will provide help and support with respect to organising rotations and/or specialist training that might require national coordination. In order to optimise the educational benefit and value of OLAT and the e-learning Portfolio, Professional Leads will also work with and support training departments in its use.

The School can be contacted on the following email: nshcs@Westmidlands.nhs.uk and at www.nshcs.org.uk.

7.2 The Academy for Healthcare Science

41. The Academy for Healthcare Science (AHCS provides the professional voice for the healthcare science workforce. Its functions are to:
• act as a strong and coherent professional voice;
• be able to influence and inform a range of stakeholders on all matters relating to healthcare science and scientific services;
• act as the overarching body for professional issues related to education, training and development in the UK health system including the provisions of UK wide quality assurance across education and training arrangements;
• provide the infrastructure to support the professional regulation/registration of the healthcare science workforce including:
  o establishing a system of professional accreditation of education and training programmes for the regulation/registration of the healthcare science workforce;
  o setting the professional standards for the delivery of accredited registers as required by CHRE (to be renamed the Professional Standards Authority for Health and Social Care) to ensure consistency and coherence across all MSC programmes;
  o taking the central role in the sponsorship of the voluntary registers to achieve ‘accredited’ status as set out by CHRE (to be renamed the Professional Standards Authority for Health and Social Care);
  o becoming an HPC education provider for the statutory regulation of clinical scientists;
  o establishing a system for equivalence across the whole of the healthcare science workforce.

http://www.academyforhealthcarescience.co.uk/

The following sections of this MSc Curriculum provide an overview of the STP for the specialisms within this theme. This is followed by the Generic, Division and Themed Learning Outcomes and Indicative Content, together with the high-level work based learning outcomes.
Section 8: Professional Practice

Professional practice spans the whole of the three-year training programme, underpinning both work based training and the MSc in Clinical Science and is described in the document Good Scientific Practice. This document sets out the principles and values on which good practice undertaken by the Healthcare Science workforce is founded. Wherever possible teaching should be contextualised to patients and patient care recognising that the work of all members of the healthcare science workforce have an impact on patients and their care.

*Good Scientific Practice* sets out for the profession and the public the standards of behaviour and practice that must be achieved and maintained in the delivery of work activities, the provision of care and personal conduct.

*Good Scientific Practice* uses as a benchmark the Health Professions Council (HPC) Standards of Proficiency and Standards of Conduct, Performance and Ethics, but expresses these within the context of the specialities within Healthcare Science, recognising that three groups of the workforce, Biomedical Scientists, Clinical Scientists and Hearing Aid Dispensers are regulated by the HPC. The aim is that the standards are accessible to the profession and understandable by the public.

*Good Scientific Practice* represents standards and values that apply throughout an individual’s career in healthcare science at any level of practice. The standards will be contextualised by the role within Healthcare Science that an individual undertakes. This means that the standards must be interpreted based on the role that an individual performs. For example, in supervised roles where individuals work within defined procedures, rather than autonomously, some standards will need to be interpreted appropriately for the context of the specific role. There will, however, always be a requirement for an individual to work within the limits of their scope of practice and competence.

Students and trainees will be expected to be working towards meeting the expectations set out in this document. However, if an individual is undertaking further training and development following qualification from a professional training programme, he or she will be expected to be able to meet the standards in this document within their scope of practice.

The standards have been used to support curriculum development and will be used to underpin the process of judging individual equivalence, particularly for emerging specialisms.

The standards have been divided into five domains. The domains of *Good Scientific Practice* detailed in section 2 are:

1. Professional Practice
2. Scientific Practice
3. Clinical Practice
4. Research and development
5. Clinical Leadership

Further details including the content of each domain can be found in Appendix 3.

Within the MSc Clinical Sciences (Cardiac, Critical Care, Vascular, Respiratory and Sleep Sciences) key outcomes for trainees are for all modules are shown below.

<table>
<thead>
<tr>
<th>Learning Outcomes: Associated Personal Qualities and Behaviours (Professionalism)</th>
</tr>
</thead>
<tbody>
<tr>
<td>On successful completion of this module the trainee will:</td>
</tr>
<tr>
<td>1. Use correct terminology when discussing scientific issues.</td>
</tr>
<tr>
<td>2. Work safely in relevant areas with due regard to patient, public, staff and self.</td>
</tr>
<tr>
<td>3. Adhere to trust/employer infection control policy at all times.</td>
</tr>
<tr>
<td>4. Communicate appropriately with the patient in a professional and considerate manner.</td>
</tr>
<tr>
<td>5. Recognise the unique challenges and care required when dealing with cardiac patients.</td>
</tr>
<tr>
<td>6. Recognise clinically urgent situations and respond accordingly.</td>
</tr>
<tr>
<td>7. Present complex scientific principles in simple terms in both oral and written formats.</td>
</tr>
<tr>
<td>8. Consistently operate within a sphere of personal competence and level of authority.</td>
</tr>
<tr>
<td>9. Manage the physical and practical requirements.</td>
</tr>
<tr>
<td>10. Manage personal workload and objectives to achieve quality of care.</td>
</tr>
<tr>
<td>11. Actively seek accurate and validated information from all available sources.</td>
</tr>
<tr>
<td>12. Select and apply appropriate analysis or assessment techniques with methodical attention to detail.</td>
</tr>
<tr>
<td>13. Conduct diagnostic examinations with due care for the safety of patient, public, staff and self.</td>
</tr>
<tr>
<td>14. Interpret data and convert into knowledge for use in the clinical context of individuals and groups of patients.</td>
</tr>
<tr>
<td>15. Work in partnership with colleagues, other professionals, patients and their carers to maximise patient care.</td>
</tr>
</tbody>
</table>
Section 9: MSc Clinical Science (Cardiac, Critical Care, Vascular, Respiratory and Sleep Sciences)

9.1 Overview of STP in Cardiac, Critical Care, Vascular, Respiratory and Sleep Sciences

The diagram below provides an overview of the STP each trainee in Cardiac, Critical Care, Vascular, Respiratory and Sleep Sciences will follow.

**Modernising Scientific Careers: Scientist Training Programme (STP): Diagrammatic representation of employment-based, three-year NHS commissioned, pre-registration Education and Training programme**

9.2 Cardiac, Critical Care, Vascular, Respiratory and Sleep Sciences Route Map

The route map overleaf shows how the high-level framework has been interpreted for the MSc in Clinical Science (Cardiac, Critical Care, Vascular, Respiratory and Sleep Sciences) for each of the three specialisms, namely:

i. Cardiac Science
ii. Critical Care Science
iii. Respiratory and Sleep Sciences
iv. Vascular Science
# MSc Clinical Science Route Map: Cardiac, Critical Care, Vascular, Respiratory and Sleep Sciences (CCVRS)

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction to Cardiac, Critical Care, Vascular, Respiratory, and Sleep Science – underpinning knowledge for rotational work based training [40]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Cardiac Science**
  - Diagnostic approaches and current treatment of cardiovascular disorders [20]
  - Research Project [30]
  - Ultrasound Imaging in Cardiac Disease [30] OR Diagnosis and Management of Cardiac Rhythm Disorders [30]
  - Research Project [30]

- **Critical Care Science**
  - Respiratory and Sleep Science 2 [20]
  - Excludes Sleep Component
  - Research Project in Critical Care Science [30]
  - Life Support and Emergency Resuscitation [10]
  - Monitoring and Supporting Critically Ill Patients [15]
  - Diagnostic and Therapeutic Techniques in Critical Care [5]
  - Research Project in Critical Care Science [30]

- **Respiratory and Sleep Science**
  - Respiratory and Sleep Science 1 [20]
  - Research Project [30]
  - Respiratory and Sleep Science 2 [30]
  - Research Project [30]

Route map of MSc Clinical Science (CCVRS) with specialisms in Cardiac Science, Critical Care Science, Vascular Science and Respiratory and Sleep Science. In Year 1, trainees begin by following the generic curriculum which spans all divisions (blue) together with some division/theme-specific modules (yellow). In Years 2 and 3, trainees specialise (orange).
<table>
<thead>
<tr>
<th>Credits</th>
<th>Generic</th>
<th>Division/Theme</th>
<th>Specialism</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vascular Science</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultrasound Science, Haemodynamics and Instrumentation [20]</td>
<td>20</td>
<td>40</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>Extracranial Arterial (Imaging) [10]</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Venous [10]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peripheral Arterial (Screening and microvasculature diagnostics Research Project [30]</td>
<td>30</td>
<td>0</td>
<td>60</td>
<td>90</td>
</tr>
</tbody>
</table>

Total Credits: 60

Generic: 20
Division/Theme: 40
Specialism: 50
Total: 60
Section 10: Generic Modules

Generic Curriculum

The generic STP MSc Clinical Science curriculum followed by all trainees comprises three modules:

- Introduction to Healthcare Science, Professional Practice and Clinical Leadership: Year 1
- Research Methods: Year 2
- Research Project: Years 2 and 3

The generic STP work based programme generic curriculum modules are:

- Professional Practice: Years 1, 2 and 3
- Elective: following completion of the rotational training programme

These modules align to Good Scientific Practice (see Appendix).

**Year 1: Generic Module**

**Introduction to Healthcare Science, Professional Practice and Clinical Leadership**

[20 credits]

The overall aim of this introductory module is to provide all trainees with a broad knowledge and understanding of science and scientific knowledge, contextualised to the practice of healthcare science and the services provided by their healthcare science division/specialism. Central to this is the contribution of healthcare science to patient care, patient safety, service delivery, research and innovation, often at the cutting edge of science, for example genomics and bioinformatics. All members of the healthcare science workforce must understand the impact of their work on patients and patient care and remember that their work has a direct or indirect impact on patient care.

It is recognised that some of the learning within this module will not be at master’s level, as allowed for in university regulations, but achievement of each learning outcome provides the building blocks for the division- and specialism-specific learning to follow, ensuring a common starting point for all trainees. While some of the learning may be at a lower level, the application of that knowledge in the divisional and specialist modules will be at master’s level.

As an introductory module it is expected to provide an overview and reinforcement of key concepts with respect to the organisation, structure and function of the body, and important areas such as the psychosocial aspects of health and disease, clinical pharmacology and therapeutics, genomics and bioinformatics.
A major focus of this module is professional practice. This module will introduce and critically review the frameworks and academic literature underpinning professional practice and enable trainees to gain the knowledge, skills, experience and tools to develop, improve and maintain high standards of professional practice at all times.

**Learning Outcomes: Knowledge and Understanding**

On successful completion of this module the trainee will:

**Scientific Basis of Healthcare Science**
1. Describe the cellular, tissue and systems responses to disease and discuss those body systems and processes relative to your division/specialism.
2. Explain the main principles and core concepts of clinical genetics and genomics and discuss in the context of patients referred to services provided by your division/specialism.
3. Explain the main principles and core concepts of the sociology of health and illness and discuss those relevant to patients and the role of your division/specialism.
4. Explain the basis of epidemiology, public health and health protection and discuss in relation to patients and the safety of patients referred to services provided by your division/specialism.
5. Explain the basic principles of clinical pharmacology and therapeutics and discuss in relation to patients and the safety of patients referred to services provided by your division/specialism.
6. Explain the basic principles of physics that underpin healthcare science and discuss in relation to patients and the safety of patients referred to services provided by your division/specialism.
7. Discuss and justify how bioinformatics, including large biological datasets, contributes to patient safety, patient care and the practice of healthcare science and defend the governance and ethical frameworks within which bioinformatics can be used.

**Professional Practice**
8. Discuss and appraise the ethical foundations of professionalism, including critical reflection, and how these relate to the clinical scientist, the patient, the practice of healthcare science and the wider healthcare environment.
9. Explain and critically evaluate the structures, processes and methodologies that underpin the quality of the service provided by the NHS and quality improvement initiatives to promote high quality patient care and enhance patient safety, and discuss the quality mechanisms relevant to your division/specialism.
10. Explain the principles of effective written and verbal communication and feedback, considering the needs and dignity of patients, the public, health professionals and scientists.
11. Describe and evaluate the basic principles and structures underpinning history taking, clinical examination and clinical decision making and discuss their role in your division.
Clinical Leadership
12. Discuss, compare and contrast a range of leadership models, including those that underpin current NHS Leadership and Competency Frameworks, and identify and critically evaluate how your personal values, principles and assumptions affect your personal leadership style.
13. Explain the current structure and management of health and social care systems and services at a national (UK-wide) and local level and the way in which the voice of patients and the public is embedded in all aspects of healthcare and healthcare education.

Learning Outcomes: Practical Skills

On successful completion of this module the trainee will:

1. Practise the skill of history taking.
2. Practise the skill of giving and receiving meaningful feedback.

Indicative Content

Review of the organisation, structure and function of the body
- Chemical, cellular and tissue level of organisation of the body
- Metabolism
- Function of blood as a tissue, blood cells (types and life times)
- Anatomy and physiology:
  - skin
  - skeletal system
  - respiratory system
    - ventilation
    - gas exchange
    - blood gas transport
  - heart, blood vessels and lymphatic system
- Central, peripheral and autonomic nervous system
- Vision, hearing and equilibrium
- GI tract, including digestion and absorption of food, the liver and liver function tests
- Renal system
- Endocrine system
- Electrolyte and acid-base balance
- Hormonal mechanisms and control
- Abdomen, pelvis and perineum, including male and female reproductive tract

Review of pathophysiology: cellular, tissue and systems responses to disease
- Review of the pathological processes underpinning common diseases:
  - cell death
  - inflammation
  - neoplasia
  - hypertrophy

Learning Outcomes: Practical Skills

On successful completion of this module the trainee will:

1. Practise the skill of history taking.
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Indicative Content

Review of the organisation, structure and function of the body
- Chemical, cellular and tissue level of organisation of the body
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- Electrolyte and acid-base balance
- Hormonal mechanisms and control
- Abdomen, pelvis and perineum, including male and female reproductive tract

Review of pathophysiology: cellular, tissue and systems responses to disease
- Review of the pathological processes underpinning common diseases:
  - cell death
  - inflammation
  - neoplasia
  - hypertrophy
- hyperplasia
- tissue response to injury and repair

**Introduction to the main principles and core concepts of clinical genetics and genomics**
- Meiosis and Mendelian inheritance
- Nucleic acid structure and function
- Chromosome structure and function
- Nomenclature used to describe the human genome
- Common genetic disorders
- Impact of genetic disorders on the patient and their families
- Genomic technology and role of the genome in the development and treatment of disease

**Introduction to sociology of health and illness**
- Factors affecting health and their contribution to inequalities in health between populations
- Basis of health protection, including principles of surveillance
- Patients’ responses to illness and treatment, including the impact of psychological and social factors including culture, on health and health-related behaviour
- Health belief models
- Diversity of the patient experience
- Disability, including learning disabilities
- Potential health inequalities
- Self-care
- Impact of life-threatening and critical conditions
- Patient involvement in decisions regarding their healthcare

**Introduction to epidemiology, public health and health protection**
- Health and disease in population terms
- The importance of population factors in individual health/disease processes
- Data interpretation, including the variability of biological data and application of statistics
- Investigating disease, epidemiology and natural history, including mathematical modelling
- Role of local, national and international bodies associated with health protection
- Principles of surveillance, the characteristics of different surveillance systems and key current policies and programmes used to protect health
- Screening programmes, including design, strengths and weaknesses

**Introduction to clinical pharmacology and therapeutics**
- Overview of the basic principles of pharmacokinetics
- Overview of the basics of drug metabolism and excretion
- Basic mechanisms and clinical importance of drug interactions

**Basic principles of physics underpinning common measurement techniques used in healthcare science**
• Structure of matter (atomic and nuclear models)
• Radiation: nature and its measurement and radiation safety
• Physics and mathematics of image formation
• Basic electricity and magnetism as it relates to the measurement of physiological signals
• Viscous and inertial flow of simple liquids

Ethical foundations of professionalism and the patient at the centre of care
• Defining professionalism within health and healthcare science
• Characteristics (personal traits) that impact on professionalism and professional practice in the workplace
• Ethical, legal and governance requirements arising from working at the level of the Clinical Scientist
• Critical Reflective Practice
  o Evidence base
  o Reflection as a structure for learning
  o Frameworks that support critical reflective practice
  o Reflection to improve professional practice
  o Reflection as a model for developing deep learning
  o Reflection as a means of improving patient care, service delivery and scientific investigation

Introduction to quality, quality improvement
• Patient safety
• Definition of terms
• Quality management
• Quality control
• Quality assurance
• Quality improvement
• Quality methodologies
• Quality processes and procedures
• Clinical governance
• Current NHS quality management and improvement systems
• Quality assurance to protect patients and assure high-quality healthcare science services, and deliver safe and effective services

Introduction to history taking, clinical examination
• Importance of patient-centred care, treating patients with respect, honesty and compassion, maintaining patient dignity and confidentiality and putting the patient first
• Duty of candour and the importance of this in healthcare
• Informed consent
  o Principles, guidance and law with respect to informed consent
  o Introduction to the patient, including role of the Clinical Scientist
  o Explanation to the patient
• Structured models for presenting a patient history
• Process of patient-centred interviewing and the features of a good consultation
  o Initiating the session
• Gathering information
• Building the relationship
• Explaining and planning
• Closing the session
• Link between the patient history and examination and development of clinical investigation and management plans
• Shared clinical decision making
• How information from a history and examination is used to develop clinical management plans

**Introduction to communication skills**
• Principles of effective communication, including:
  o written and electronic
  o verbal
  o non-verbal
• Importance of:
  o signposting
  o listening
  o paraphrasing
  o language
  o commonly used questioning techniques
  o non-verbal behaviour
  o ideas
  o beliefs
  o concerns
  o expectations
  o summarising
  o communication
• Range of question types that can be used in a communication
• Key features of effective patient interviews and information giving
• Adapting communication methods for people/groups/culture
• Feedback
  o The role of feedback in clinical education and continuing professional development
  o Feedback models
  o Characteristics of effective feedback

**Introduction to leadership within the NHS**
• Theories and models of leadership
• Concept of shared leadership
• Associated personal qualities and behaviours that promote shared leadership
• Overview of the NHS Leadership Framework and Clinical Leadership Competency

**Introduction to the structure of the NHS**
• Structure of the NHS across the four UK countries
  o Structure
  o Accountabilities
  o Funding arrangements
Working relationships

- NHS Constitution
  - The seven key principles that guide the NHS in all it does
  - NHS Values
    - Respect and dignity
    - Commitment to quality of care
    - Compassion
    - Improving lives
    - Working together for patients
    - Everyone counts
- Quality improvement structures and processes within the NHS
- Patient safety and the requirement to protect patients from avoidable harm
- Patient focus
  - Shared decision making with patients
  - Access to information
  - Choice
  - Personalised care
  - Safeguarding patients

Year 2: Generic Module
Research Methods
[10 credits]

The overall aim of this module is to ensure that the trainee has the knowledge, skills and experience of the role of research, development and innovation in the NHS in improving patient care, including prevention, diagnostics, treatment and service delivery. On completion of this module and the research project, trainees should be able to generate ideas; assess, plan, conduct, evaluate, interpret and report research and innovation projects, which includes original research; and disseminate the findings and, where appropriate, the adoption of the findings. Trainees should also be able to use research to improve practice.

Learning Outcomes: Knowledge and Understanding

On successful completion of this module the trainee will:

1. Discuss and critically evaluate the context within which research, development, innovation and audit are undertaken to improve patient care, promote innovation and improve service delivery.
2. Describe, compare and contrast a range of research methods/approaches, including cohort studies, qualitative, quantitative, systematic review, sampling techniques and clinical trials.
3. Explain and justify current UK ethical and governance frameworks and processes spanning the conduct of human and animal research, innovation and audit.
4. Critically evaluate the literature/evidence base to identify a research question and create a new approach or technique to improve patient care or service delivery.
5. Discuss and justify the research, audit and innovation process from idea
generation to dissemination/implementation, including patient/user involvement and intellectual property.

6. Describe and evaluate a range of data analysis techniques to ensure the validity, reliability and appropriateness to the research aim, design and conclusion.

7. Describe how clinical guidelines are produced and the concept of evidence-based practice, including the role of current statutory and advisory regulatory bodies.

8. Identify potential sources of research and innovation funding for healthcare science/Clinical Scientists.

**Learning Outcomes: Practical Skills**

On successful completion of this module the trainee will:

1. Undertake an evidence-based literature review, critically appraise the output, draw appropriate conclusions and report the findings, and where appropriate, use the findings to inform a research project.

2. Identify, discuss and critically evaluate a research, innovation, or audit project that has resulted in an improvement in patient care, diagnostics or service delivery.

**Indicative Content**

**Research methods/approaches**
- Differentiation between audit and research
- Cohort studies
- Qualitative
- Quantitative
- Systematic review
- Meta-analysis
- Sampling techniques
- Clinical trials (pre-clinical to translational)
- Epidemiological studies
- Study design
- Hypothesis generation and testing

**Ethical and governance research frameworks**
- Good Clinical Practice (GCP)
- Human research
- Animal research
- Innovation
- Audit

**Research, audit and innovation process**
- Literature searching and referencing
- Innovation pathway (Invention, Evaluation, Adoption and Diffusion)
- Idea generation
- Patient/user involvement
- Peer/expert review
• Practical and financial criteria and constraints affecting research
• Dissemination/implementation
• Intellectual property
• Quality assurance
• Monitoring and reporting
• Archiving
• Roles and responsibilities of the research/innovation team

Data analysis techniques
• Data validity, reliability and appropriateness
• Application and interpretation of statistical techniques
• Power calculations
• Intention-to-treat analyses

Clinical guidelines
• Evidence-based practice
• Statutory and advisory regulatory bodies

Research and innovation funding
• Sources of funding including research councils and charities
• Grant applications
Section 11: Division/Theme-Specific Modules

This section covers the division/theme specific module that will be studied by all trainees undertaking the Cardiac, Vascular, Respiratory and Sleep Sciences programme.

<table>
<thead>
<tr>
<th>Division:</th>
<th>Physiological Sciences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theme:</td>
<td>Cardiac, Critical Care, Vascular, Respiratory and Sleep, Gastrointestinal Physiology and Urodynamic Sciences</td>
</tr>
<tr>
<td>Year 1:</td>
<td>Introduction to Cardiac, Vascular, Respiratory and Sleep Sciences</td>
</tr>
<tr>
<td></td>
<td>[40 credits]</td>
</tr>
</tbody>
</table>

The overall aim of this module is to provide trainees with the knowledge that underpins the four rotations that trainees follow in the Cardiac, Critical Care, Vascular, Respiratory and Sleep Sciences and Clinical Assessment and Investigation.

**Trainees in Cardiac, Vascular, or Respiratory and Sleep Science complete rotations A, C, D and E, and trainees in Critical Care Science rotations A, B, C and F.**

A high-level description of the work based learning is included to provide MSc Clinical Science providers with information on how the academic and MSc elements of each STP programme integrate. The full work based Learning Guide can be found at:


<table>
<thead>
<tr>
<th>Division:</th>
<th>Physiological Sciences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theme:</td>
<td>Cardiac, Critical Care, Vascular, Respiratory and Sleep, Gastrointestinal Physiology and Urodynamic Sciences</td>
</tr>
<tr>
<td>Rotation A:</td>
<td>Introduction to Cardiac Science</td>
</tr>
<tr>
<td>Rotation B:</td>
<td>Introduction to Critical Care Science</td>
</tr>
<tr>
<td>Rotation C:</td>
<td>Introduction to Respiratory and Sleep Science</td>
</tr>
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**Rotation A**

**Introduction to Cardiac Science**

**[10 credits]**

This rotation will provide trainees with the knowledge and understanding of resting and ambulatory electrocardiography and blood pressure measurement so that they can perform simple cardiac investigations.

**Learning Outcomes: Knowledge and Understanding**
On successful completion of this module the trainee will:

1. Describe the anatomy and physiology of the cardiovascular system and apply and extend knowledge to Cardiac Science.
2. Explain the range of basic equipment and techniques used in Cardiac Science and discuss the application of safe and effective clinical practice.
3. Describe and evaluate the role of cardiac physiology in the patient pathway across primary/community care, secondary care and one-stop clinics.
4. Describe the principles of physics and instrumentation underpinning the routine diagnostic investigations and procedures in Cardiac Science.
5. Explain the concept of ‘normal’ and the calculation and use of normal ranges, and recognise the normal physiological variability in humans.
6. Describe the clinical framework, normal ranges, calibration and quality assurance for, and basic principles of:
   - Clinical electrocardiography
   - The normal ECG from birth to old age
   - Common and life-threatening arrhythmias
   - Development of a framework for interpretation of ECGs
   - Blood pressure measurement
   - Ambulatory blood pressure recording
   - Ambulatory electrocardiography
   - Signal averaged ECG
   - The practice and principles of provocative testing
7. Describe the basic cardiac chest X-ray
8. Gain experience of the linkages between the Cardiac Science and other clinical specialisms in the investigation of diseases of the cardiac system.

Introduction to Cardiac Science (CS-1)

Learning Outcomes: Associated Work Based Learning

High-level description of the work based learning that accompanies this academic module. Further details of the work based programme can be found in the Work Based Learning Guide, including the Clinical Experiential Learning, Competences and Applied Knowledge and Understanding.

On successful completion of this module the trainee will:

1. Plan and perform a resting ECG in a range of patients in a variety of clinical settings, to current nationally accepted standards.
2. Recognise normal and abnormal ECG results, particularly myocardial infarction and life-threatening arrhythmias.
3. Set up a patient for cardiac monitoring.
4. Plan and perform BP measurement on a range of patients, using manual and automatic methods.
5. Fit ambulatory ECG equipment, including patient instruction.
6. Critically analyse ambulatory ECG recordings and produce a report under clinical supervision.
7. Fit ambulatory BP equipment, including patient instruction, and produce the results in the appropriate format.

Indicative Content

Introduction to Cardiac Science
- Normal anatomy and physiology of the cardiovascular system
- Investigations and procedures carried out in the diagnosis and treatment of cardiac disease
- Characteristics of recording equipment and their evaluation
- Basic cardiac electrocardiography
- Recognition and interpretation of normal ECG waveforms
- Signal averaged ECG
- Control of the circulation
- Cardiac embryology and fetal heart development
- Atherosclerosis and its relationship with ischaemic heart disease
- Heart failure and its effect on the cardiovascular system and other body systems
- Main clinical applications/diagnostic techniques in cardiac science
- Normal ranges

Planning and preparing for each investigation
- Indications for and contraindications to testing
- Adherence to health and safety of patient, public, staff and self
- The requirements for pre-test instructions and their implications on testing
- Basic clinical assessment of patients
- Monitoring of patients during assessment
- The requirements for accurate demographics and patient data
- Patient confidentiality and Data Protection Act
- Basic principles of infection control
- Knowledge of local and national guidelines specific to procedure

In this module trainees will develop detailed learning that underpins the routine practical techniques:
- Clinical 12-lead electrocardiography
  - Characteristics of recording equipment
  - Components and functions
  - Settings and adjustments made based on patient category
  - Recommended measurement technique
- Development of a framework for interpretation of standard 12-lead ECGs
  - The normal ECG from birth to old age
    - Anatomy
    - Physiology
    - Leads
    - Rate
    - Rhythm
    - Cardiac axis
• Terminology
  ▪ Normal sinus rhythm
• Recognition of life-threatening arrhythmias
  o Ventricular tachycardia
  o Torsades de Pointes
  o Ventricular fibrillation
  o Asystole/p-wave asystole
  o Pulseless electrical activity (PEA)
• Myocardial infarction and ischaemia
• Recognition of common arrhythmias
  o Sinus arrhythmia
  o Sinus bradycardia
  o Sinus tachycardia
  o Atrial fibrillation
  o Atrial flutter
  o Atrial ectopics
  o Atrial tachycardia
  o AV nodal re-entrant tachycardia
  o AV re-entrant tachycardia
  o Atrioventricular conduction blocks
  o Ventricular ectopics/bigeminy/trigeminy
  o Ventricular arrhythmias
• Ambulatory electrocardiographic recording
  o Characteristics of recording equipment
  o Indications
  o Limitations and optimisation of recording
  o Common problems
  o Analysis, presentation and evaluation of results
• Routine blood pressure measurement
  o Principles and limitations of range of recording equipment used to measure blood pressure
    ▪ Mercury and aneroid sphygmomanometers
    ▪ Electronic devices including wrist devices
    ▪ Device calibration
  o Indications for blood pressure measurement
  o Factors affecting blood pressure, including diurnal variation and white coat hypertension
  o Recommended measurement technique
  o Common errors in blood pressure measurement
    ▪ Observer
    ▪ Equipment
    ▪ Patient
    ▪ Cardiac arrhythmias
  o Normal blood pressure ranges
  o Definition of hypertension
• Ambulatory blood pressure recording
  o Characteristics of recording equipment
  o Indications
  o Contraindications
  o Recommended measurement technique
• Normal ranges
• Common problems
• Analysis, presentation and evaluation of results
• Features of a normal chest X-ray
  • Proportional heart size
  • Aortic root
  • Aortic arch
  • Lung fields/Kerley lines
  • Diaphragm position

**Rotation B**
**Introduction to Critical Care Science**
[10 credits]

This rotation will provide trainees with the knowledge and understanding to enable them to perform a range of procedures in a critical care environment.

### Learning Outcomes: Knowledge and Understanding

On successful completion of this module the trainee will:

1. Describe and explain the role of the Critical Care Scientist (CCS) in the care of patients and within the healthcare team.
2. Describe infection control, risks and emergency procedures within the critical care environment.
3. Know the criteria for admission to, and discharge from the intensive care unit (ICU), including factors influencing intensity and site of care (ward, high dependency unit [HDU], ICU).
4. Describe the pathophysiology of common diseases that result in admission to an ICU.
5. Recall and apply knowledge of basic healthcare science with respect to the cardiovascular, respiratory and renal systems to explain a range of typical patient scenarios relevant to critical care science.
6. Explain how to recognise and respond to adverse trends in monitored parameters.
7. Describe the principles of ECG monitoring.
8. Describe the clinical framework for and basic principles of the following within a critical care environment:
   • patient monitoring systems
   • date interpretation and management
   • oxygen therapy techniques
   • blood gas analysis.
9. Recognise the legal and ethical issues arising from caring for an acutely ill patient.
10. Explain and justify the use of the Alert, Voice, Pain, Unresponsive (AVPU) system in the care of critically ill patients.

### Learning Outcomes: Associated Work Based Learning
High-level description of the work based learning that accompanies this academic module. Further details of the work based programme can be found in the Work Based Learning Guide, including the Clinical Experiential Learning, Competences and Applied Knowledge and Understanding.

On successful completion of the trainee will:

1. Use correct aseptic technique and aseptic handling of medical devices in the critical care environment.
2. Perform a range of bedside monitoring techniques* and be able to interpret acute events and actions required, differentiating between physiological and technical abnormalities in patient monitoring techniques.
3. Administer oxygen therapy across a range of delivery systems to critically ill patients.
4. Perform a blood gas measurement and describe its clinical relevance.
5. Correctly store medical gases, ensuring adherence to the safety issues in the context of the critical situation.
6. Use the National Early Warning Scoring system in relation to critical care.

*This should include ECG monitoring, oxygen saturation monitoring and non-invasive BP monitoring

Indicative Content

Techniques and functions performed by a critical care scientist
- Physiological support, measurement and clinical intervention including: respiratory, cardiovascular, renal and hepatic, neurological and gastrointestinal
- Health and Safety, Risk Assessment and Clinical Governance

Common respiratory, cardiac and metabolic diseases resulting in ICU admission, including:
- Asthma
- Chronic lung disease
- Pneumonia and respiratory tract infections
- Chest trauma
- Ischaemic heart disease
- Circulatory collapse/shock
- Cardiac arrhythmia
- Biochemical, endocrine or metabolic derangement
- Common congenital cardiac disorders

Anatomy and physiology of the cardiovascular system

Respiratory system
- Control of respiration
- Diseases affecting gas transfer in the respiratory system.
• Physical limitations of gas movement within the respiratory tract
• Ventilation/perfusion matching

**Cardiovascular system**
• Structure and function of blood vessels
• Coronary circulation
• Capillary exchange
• Factors affecting blood flow
• Control of blood pressure and flow
• Shock and homeostasis
• Circulatory routes
• Cardiac output
• Cardiac cycle
• Normal and abnormal haemodynamic and ECG response to exercise
• Overview of pathophysiology of acquired, congenital and ischaemic heart disease

**Renal system**
• Structure and function of the kidneys
• Evaluation of kidney function
• Factors affecting renal function/perfusion

**Blood**
• Characteristics
• Haemostasis
• Blood groups and types
• Typing and cross-matching
• Clotting cascade
• FBC

**Fluid, electrolyte and acid-base homeostasis**
• Fluid compartments and fluid balance
• Oedema

**Infection control**
• Types of organisms
• Modes of transfer
• Protective strategies

**ECG monitoring**
• Heart rate
• Rhythm
• Conduction
• ST segment change
• QT interval
• Indications
• Limitations
• Techniques
• Advantages and disadvantages of different lead configurations
Devices used in the treatment of critically ill patients

- Type of devices used in the treatment of critically ill patients
- Scientific principles of minimal patient monitoring systems
- Application of minimal patient monitoring techniques
- Normal/abnormal and artefacts and inaccuracies associated with outputs from minimal patient monitoring systems
- Clinical significance of outputs from minimal patient monitoring systems
- Essential services and the relevant safety systems
- Ventilation and the process of ventilation
- Suction devices
- Syringe drivers
- Computers and data recording systems
- Storage of medical gases and the safety issues
- National Early Warning Scoring system in relation to Critical Care.

Rotation C
Introduction to Respiratory and Sleep Science (RS&S-2)
[10 credits]

This rotation will provide trainees with the knowledge and understanding of respiratory and sleep diagnostics to underpin the work based learning.

Learning Outcomes: Knowledge and Understanding

On successful completion of this module the trainee will:

1. Describe the anatomy of the respiratory system, including structure and function, control of breathing (nocturnal and diurnal) and apply and extend knowledge to the specialism of Respiratory and Sleep Science.
2. Discuss the diversity of respiratory and sleep disorders that result in referral to the service, including the pathophysiology of common lung and sleep disorders causing excessive daytime hypersomnolence and presenting signs and symptoms.
3. Describe and evaluate the range of respiratory and sleep science diagnostic techniques used to diagnose, monitor and manage disorders of respiration and of sleep.
4. Describe the measurement principles of the techniques used to assess full lung function tests and overnight oximetry, recognising the limitations of equipment and techniques used.
5. Describe the range of reference values used in the assessment of normality and the use of guidelines to assess disease severity.
6. Discuss how respiratory and sleep diagnostic techniques are utilised in the primary/community care setting.
7. Critically evaluate the role of quality assurance in the maintenance of equipment used in the diagnosis of respiratory and sleep disorders.

Learning Outcomes: Associated Work Based Learning
High-level description of the work based learning that accompanies this academic module. Further details of the work based programme can be found in the Work Based Learning Guide, including the Clinical Experiential Learning, Competences and Applied Knowledge and Understanding.

On successful completion of this module the trainee will:

1. Perform, analyse and develop skills in the interpretation of routine spirometry in patients referred for routine investigation.
2. Perform, analyse and develop skills in the interpretation of the measurement of lung volumes in patients referred for routine investigation.
3. Perform, analyse and develop skills in the interpretation of the measurement of gas transfer.
4. Perform, analyse and develop skills in the interpretation of overnight oximetry studies.
5. Perform a limited multichannel sleep study.
6. Assist in the routine maintenance, calibration and quality assurance procedures on the equipment used to undertake spirometry lung volumes, measurement of overnight pulse oximetry and continuous positive airway pressure (CPAP) equipment.
7. Document local patient diagnostic and treatment pathways (e.g. chronic obstructive pulmonary disease [COPD] and obstructive sleep apnoea hypoventilation syndrome [OSHAS]).

Indicative Content

Introduction to respiratory physiology and sleep
- Normal anatomy and physiology of the respiratory and sleep systems
- Control of breathing
- Development of the respiratory system
- Respiratory mechanics
- Basic full lung function testing
- Investigations and procedures carried out in the diagnosis and treatment of respiratory disease and sleep disorders
- Basic assessments of sleepiness and measurement techniques

Planning and preparing for investigations
- Indications for and contraindications to testing
- Health and safety, including safe handling of reagents
- The requirements for pre-test instructions and their implications on testing
- Basic clinical assessment of patients
- Monitoring of patients during assessment
- The requirements for accurate demographics and patient data
- Patient confidentiality and Data Protection Act

Investigations
- Spirometry
  - Flow and volume measuring devices
  - Advantages and disadvantages of different measuring devices
Measurement parameters, to include FEV₁, FVC, VC, PEF, FEV₁/FVC ratio, FEV₁/VC ratio, FEF, PIF
- Acceptability and reproducibility
- Common errors in measurement

Lung volumes
- Methods for measuring lung volumes
- Advantages and disadvantages of different measuring devices
- Measurement and calculated parameters, to include VC, FRC, TGV, ERV, RV, TLC
- Acceptability, reproducibility and end points
- Common errors in measurement
- Gas analysers
- Gas cylinders and special gases used in diagnostic investigations
- Relevant gas laws and Boyle’s Law

Gas transfer
- Methods for measuring gas transfer
- Advantages and disadvantages of different measurement techniques
- Acceptability, reproducibility and end points
- Measurement parameters, to include TLCO, KCO and VA
- Common errors in measurement

Oximetry
- Uses of oximetry, e.g. spot check and overnight monitoring
- Interpretations and limitations of overnight studies
- Measurement principles
- Definitions, e.g. SpO₂ and SaO₂, desaturation, hypoventilation
- Artefact identification

Multi channel sleep studies
- Advantages and disadvantages of multichannel studies when compared to other methods of sleep analysis
- Measurement principles
- Definitions of commonly measured parameters and events, e.g. central and obstructive apnoeas and hypopnoeas, sleep stages, arousals

Interpretation/Reporting
- Differentiate between normal, obstructive and restrictive spirometry
- Effects of common respiratory pathology on lung volumes and gas transfer. Pathology to include COPD, asthma, interstitial lung disease, chest wall disorders, neuromuscular disorders and obesity
- An awareness of the impact of other factors on investigation results, e.g. anaemia, polycythaemia and carbon monoxide
- Identification of normal and abnormal oxygen saturations
- Identification of abnormal sleep stage distributions

Reference equations
- Parameters for assessment of normality, e.g. percentage of predicted, standardised residuals and normal ranges
- Limitations of current reference equations
- Selection of equations according to age and race

Guidelines
- ATS/ERS Standards (2005)
- NICE CPAP HTA (2009)
- NICE COPD Guidelines (2010)

**Calibration and quality assurance**
- Characteristics of measuring equipment and their evaluation
- Routine care of gas analysers
- Linearity testing
- Definitions of calibration, verification and quality control
- Use of biological and physical quality control

**Infection control**
- Communicable diseases and microbiological hazards
- Sterilisation and disinfection methods
- Common methods for prevention of cross-infection
  - Hand washing
  - Bacterial filters
  - Single patient use items

**Principles of calibration and quality assurance for all measurements undertaken in Respiratory and in Sleep Science**
- Normal variability for each of the procedures performed
- Application of quality control strategies to ensure accuracy of results
- Mean, coefficient of variation, standard deviation, run control charts
- Diurnal variability and external influences
- How to deal with errors and equipment faults

**Emergencies**
- Recognition of life-threatening events/deterioration of patient
- Awareness of emergency procedures

**Rotation D**

**Introduction to Vascular Science (VS-3)**

[10 credits]

This rotation will provide trainees with the knowledge and understanding of how vascular science contributes in the diagnosis and monitoring of patients with a variety of vascular diseases.

**Learning Outcomes: Knowledge and Understanding**

On successful completion of this module the trainee will:

1. Recall the structure and function of blood vessels, capillary exchange, factors affecting blood flow, control of blood pressure and flow and circulatory routes.
2. Explain the diversity of vascular disease, patients and presenting symptoms, and recognise the expected co-morbidity associated with
vascular disease and the health and safety risks during the investigation.

3. Describe and evaluate the range of vascular science diagnostic techniques used to diagnose and monitor vascular diseases across a range of healthcare settings.

4. Describe the use of angiography, computerised tomography (CT) and magnetic resonance angiography (MRA) in the diagnosis of vascular disease.

5. Explain the basic practical and scientific principles and recognise when the use of an ankle brachial pressure index (ABPI) measurement is clinically indicated.

6. Explain and justify the range of surgical, endovascular and medical options used to treat vascular disease.

7. Explain the basic practical principles of obtaining a vascular ultrasound image.

8. Explain the infection risks associated with vascular ultrasound and cerebrovascular patients and how they are managed.

Learning Outcomes: Associated Work Based Learning

High-level description of the work based learning that accompanies this academic module. Further details of the work based programme can be found in the Work Based Learning Guide, including the Clinical Experiential Learning, Competences and Applied Knowledge and Understanding.

On successful completion of this module the trainee will:

2. Plan, prepare and acquire an ankle brachial pressure index (ABPI) from a range of adult patients.
3. Interpret the results of ABPI measurement, differentiating between normal and abnormal results.
4. Plan, prepare and acquire a vascular ultrasound image in both transverse and longitudinal views.

Indicative Content

Structure and function of blood vessels, capillary exchange, factors affecting blood flow, control of blood pressure and flow and circulatory routes

Overview of peripheral vascular diseases and symptoms

- Nature of peripheral vascular disease
  - Atherosclerosis
  - Arteritis
  - Aneurysmal disease
  - Dissection
  - Microvascular disease
  - Arterial thrombosis
  - Trauma, punctures and false aneurysms
  - AV malformations/fistulas
  - Venous thrombosis
o Venous incompetence
  o Extrinsic compression

- Anatomy of peripheral arterial disease
  o Extracranial and intracranial arterial disease
  o Lower extremity arterial disease (aorta-ankle)
  o Mesenteric and portal arterial disease
  o Aortic disease and aneurysms
  o Renal artery disease
  o Raynaud’s disease

- Peripheral arterial disease symptoms
  o Stroke
  o Transient ischaemic attack
  o Vertebrobasilar insufficiency
  o Thoracic outlet syndrome
  o Acute mesenteric ischaemia
  o Chronic mesenteric angina
  o Portal hypertension and liver disease
  o Swelling and tenderness (abdominal/groin/popliteal fossa)
  o Intermittent claudication
  o Chronic limb ischaemia, ulcers and gangrene
  o Renovascular hypertension
  o Raynaud’s disease

- Peripheral venous disease
  o Deep venous thrombosis
  o Superficial thrombophlebitis
  o Venous incompetence
  o Post-thrombotic syndrome

- Peripheral venous disease symptoms
  o Limb swelling
  o Hyperpigmentation
  o Ulceration
  o Varicose veins
    - Primary
    - Recurrent

- Risk factors for peripheral vascular diseases
  o Age, smoking, hypertension, diabetes, heart disease

Range of vascular science diagnostic techniques to diagnose and monitor vascular diseases in different settings
- Primary care
- Vascular surgical clinics
- One-stop transient ischaemic attack (TIA) clinics
- One-stop deep vein thrombosis (DVT) clinics
- Hospital wards
- Theatre and recovery

Overview of vascular scientific modalities
- Ultrasound
- Imaging
- Non-imaging Doppler
- Continuous wave
- Pulsed wave
- Plethysmography
  - Infrared photoplethysmography
- Transcutaneous oximetry ($T_CPO_2$)
- Laser Doppler
- Thermography
- Capillaroscopy

### Overview of vascular science diagnostics tests

- Carotid and vertebral duplex
  - Diagnostic duplex
  - Preoperative assessment
  - Intraoperative assessment
  - Postoperative monitoring
  - Stent surveillance
- Transcranial Doppler (imaging and non-imaging)
  - Pre-carotid endarterectomy assessment
  - Intraoperative assessment
  - Sickle cell disease stroke risk
- Lower extremity arterial evaluation
  - ABPI and exercise testing
  - Segmental pressures
  - Toes pressures
  - Duplex ultrasound
- Upper extremity arterial evaluation
  - Brachial pressures
  - Exercise testing
  - Thoracic outlet assessment
  - Duplex ultrasound
- Detection of false aneurysms
  - Iatrogenic injury
  - IVDUs
  - Trauma
- Evaluation of arteriovenous fistulas
- Vein graft surveillance
  - In-situ saphenous vein bypass
  - Reversed saphenous vein bypass graft
  - Prosthetic veins grafts
- Renal artery duplex
- Renal transplant duplex
- Portal and mesenteric duplex
- Evaluation of dialysis access grafts
  - Pre-fistula assessment
  - Post-fistula monitoring
- Aneurysmal disease
  - Peripheral artery aneurysms
  - Aortic aneurysms and screening programme
- Preoperative vein mapping
- Evaluation of lower extremity acute venous thrombosis
- Deep venous thrombosis (DVT) duplex
- Superficial thrombophlebitis duplex
- Evaluation of upper extremity acute venous thrombosis
  - Deep venous thrombosis (DVT) duplex
  - Superficial thrombophlebitis duplex
  - PICC line assessment
- Evaluation of chronic venous disease (post thrombotic incompetence)
  - Venous duplex
  - Infrared photoplethysmography (PPG)
    - Venous refilling times
    - Venous outflow
- Evaluation of varicose veins
  - Site of incompetence
  - Preoperative marking
  - Intraoperative guidance for endovascular procedures
- Evaluation of microvascular system

**Other diagnostic techniques**
- Angiography, MRA, CT

**Treatment including risks and benefits**
- Surgery
  - Carotid endarterectomy
  - Thoracic outlet
  - Open Abdominal Aortic Aneurysms (AAA)
  - Aorto-bifem, fem-pop
  - Open Varicose Vein (VV) – high ties, etc.
  - AV fistulas
- Endovascular
  - Endovascular AAA repair
  - Endovascular VV
  - Percutaneous transluminal angioplasty
  - Stents
- Ultrasound compression
- Duplex guided thrombin injection
- Medical therapies
- Risk factor modification

**The basic practicalities of non-imaging Doppler**
- Evaluation of peripheral vascular disease with an ABPI
  - Risk assessment and infection control
  - Patient preparation
  - Explanation of test
  - History taking
  - Patient positioning
  - Procedure and protocol
  - Recognition of normal and abnormal signals
  - Systolic blood pressure measurement using manual cuff and CW Doppler
The basic practicalities of vascular ultrasound imaging

- Obtaining an ultrasound image
- Relationship between ultrasound transducer and ultrasound image
- Very basic controls – gain, depth, focus

Rotation E
Clinical Assessment and Investigation (CA&I)
[10 credits]

This rotation will provide the trainee with the opportunity to apply their knowledge and basic skills of clinical assessment and investigation used in the diagnosis, care and treatment of patients with cardiovascular, respiratory and sleep problems across a range of clinical settings (e.g. medical assessment and integrated care, critical care and community-based services). Fundamental to this rotation is that the trainee has a thorough knowledge and understanding of cardiac, respiratory, sleep and vascular diseases and their signs and symptoms, and how they frequently interact and overlap with each other.

Integral to this module is the opportunity for the trainee to gain a greater understanding of the role of other related diagnostic modalities such as Radiology and Pathology. This module will give the trainee knowledge and understanding of the interpretation and clinical decision making associated with clinical assessment and investigations in the context of differential diagnosis together with an understanding of the principles of operation, data acquisition and quality assurance of other diagnostic service modalities.

Learning Outcomes: Knowledge and Understanding

On successful completion of this module the trainee will be able to:

Clinical Assessments and Investigations
1. Describe how different cardiac, vascular, and respiratory and sleep assessments and investigations can contribute to a holistic patient approach in the diagnosis, management, prognosis and care.
2. Explain how these assessments and investigations are used in different care environments, e.g. community, MAU, ITU/CCU, HDU.
3. Explain how frequently used clinical assessments and diagnostic investigations are selected, the clinical rationale and how they are utilised in decision making.

Imaging and Pathology Diagnostics
4. Explain the principles of and applications of diagnostic imaging (ionising and non-ionising, e.g. CT, MRI, nuclear medicine, PET, ultrasound) used to investigate structure and function in cardiac, vascular, respiratory and sleep disorders.
5. Explain the principles and applications of routine pathology tests, including normal ranges requested as part of the investigation of patients with cardiac, vascular, respiratory and sleep disorders.
6. Recognise recent advances in biomarkers and pharmacogenomics and
the impact of these new technologies in cardiac, vascular, respiratory and sleep diagnostics and treatments.

7. Explain how diagnostic imaging and pathology data are captured and stored, including issues relating to storage capacity and access to data across care delivery sectors.

8. Describe how calibration, safety testing and quality assurance procedures (including the legislative aspects of use of radiation) are applied in diagnostic imaging and pathology services, relating these to the processes used in physiological science services.

**Patient Pathways**
8. Describe patient care pathways relating to common pathological conditions associated with cardiac, vascular, respiratory and sleep disorders.
9. Discuss the major risk factors for cardiac, vascular, respiratory and sleep disorders.
10. Describe major abnormalities of physiological control mechanisms in diseases of the cardiac, vascular, respiratory and sleep systems.
11. Describe cellular, tissue and systems responses to diseases of the cardiac, vascular and respiratory systems, concentrating on disorders of growth, tissue responses to injury, cell death, inflammation, neoplasia, normal and abnormal immune responses, atheroma, thrombosis, embolism and infarction.
12. Describe the common diseases and the basis of common infections of the cardiac, vascular and respiratory systems.
13. Discuss the role of interprofessional team working in the diagnosis and treatment of patients.

**Learning Outcomes: Associated Work Based Learning**

High-level description of the work based learning that accompanies this academic module. Further details of the work based programme can be found in the Work Based Learning Guide, including the Clinical Experiential Learning, Competences and Applied Knowledge and Understanding.

On successful completion of this module the trainee will:

**Working in Partnership**
1. Record and integrate a patient history with the outcome of clinical examination and determine appropriate diagnostic investigations for patients commonly referred to cardiac, vascular, respiratory and sleep OR gastrointestinal, urodynamic science OR audiology, neurophysiology, OR ophthalmic and vision science diagnostic services in conjunction with the wider clinical team.
2. Assist in performing a range of diagnostic and therapeutic procedures, recognising abnormal results/findings and appreciating the implication of results on patient treatment and care.

**Related Diagnostic Services**
3. Identify key anatomical landmarks on images obtained using ionising and non-ionising imaging media in the investigation of patients with cardiovascular, respiratory, sleep OR with gastrointestinal and lower urinary tract (LUT) disorders OR conditions resulting in referral to audiology, neurophysiology, or ophthalmic and vision science services, and describe the limitations and impact of results on patient diagnosis, treatment and care.

4. In a supportive role assist in performing pathology tests that patients with cardiovascular, respiratory, sleep OR with gastrointestinal and LUT disorders OR conditions resulting in referral to audiology, neurophysiology, or ophthalmic and vision science services will commonly undergo as part of an individual diagnostic plan.

5. In a supportive role assist in performing safety checks, calibration and quality assurance of imaging and pathology equipment using local, national or international standards.

**Patient Pathways**

6. Devise a diagnostic plan for a patient based on the presenting symptoms and clinical information available, and indicate what the next steps might be (diagnostic or therapeutic), dependent on the outcome of the initial results from a mix of diagnostic modalities.

**Indicative Content**

**Clinical assessments and investigations**
- Signs and symptoms
- Blood pressure
- Temperature
- Respiratory rate
- Pulse rate
- Oxygen saturation levels
- Assessment of tachy and brady-arrhythmias
- Differential diagnosis of typical and atypical chest pain
- Evaluation of coronary circulation
- Valvular disease and common congenital heart diseases using echocardiography and cardiac catheterisation
- Cardiac rhythm management and implantable devise management.
- Claudication walking distance
- Wells score
- ABCD2 score.
- Level of dyspnoea
- Walking distance
- Impact on activities of daily living
- Presence or absence of chest pain
- Sputum
- Sleep: Epworth sleepiness score, snoring level

**Pathology**
- Routine blood tests, including U&E, blood gases
- Haematology
• Cardiac screen
• Clotting
• d dimers

Diagnostic imaging
• X-ray plain and contrast
• MRI
• CT
• Nuclear medicine
• Ultrasound
• Pet CT

Blood and urine glucose testing
• Point-of-care testing
• Normal ranges
• Analysis
• Quality assurance of test

ITU
• Blood gas analysis
• Central venous pressure
• Ventilatory control
• Maintenance of circulation
• Effect of inotropes
• Homeostasis

Imaging diagnostics
• Principles of technology used in radiology
  o Technology developments and advances of differential diagnosis
• Diagnostic imaging, i.e.
  o Image reconstruction techniques
  o Image display characteristics
  o Clinical application and basic understanding of normal and pathological appearances within the image
  o X-rays, X-ray production; film viewing
  o RF and magnetic fields, lasers and ultrasound
  o The physics and mathematics of image formation; radiological image; CT scanning
• Key anatomical features
  o Features of a normal chest X-ray
    • Proportional heart size
    • Aortic root
    • Aortic arch
    • Lung fields/Kerley lines
    • Diaphragm position
• Patient and personal safety management in imaging
• PACS
• CT scanning and reporting
• Ultrasound scan/imaging of soft tissue area
  o Transducers for measuring pressure and flow
• Quality assurance
• Image quality and artefacts

Patient care pathways
• Diabetes
• Breathlessness
• Wheezing
• Type 2 respiratory failure
• Sleep disorders/Sleep apnoea
• Pre-syncope/syncope
• Palpitations
• Chest pain
• Leg pain
• Renal disease
• Morbid obesity
• Stroke/TIA
• BP control

Team working
• Team formation and functions
• Role of single-discipline and multiprofessional teams in the care and management of patients
• Role of single-discipline and multiprofessional teams in the delivery of services
• Effective inter-professional team working

Cellular, tissue and systems response to common Cardiac, Vascular, Respiratory and Sleep diseases, including:
• Atheroma
• Thrombosis
• Embolism
• Inflammation
• Infarction
• Anatomical airway obstruction

Risk factors and risk assessment for cardiovascular and respiratory/sleep diseases

Basis of common infections affecting the cardiac, vascular and respiratory systems

Social issues and cardiac, vascular, respiratory and sleep diseases

The impact of smoking on health

Common diseases of the cardiac, vascular and respiratory system including the epidemiology, public health and psychosocial aspects including:

Cardiac disease
• Pathophysiology of coronary heart disease
• Preventive strategies for coronary heart disease
• Clinical presentation, diagnosis, evaluation and management of disease, to include: heart failure, valvular disease, hypertension, cardiomyopathies, cardiopulmonary disease
• Overview of rhythm and conduction disorders, syncope and sudden death, pericardial disease and endocarditis
• Essentials of congenital heart disease (ASD, VSD, PFO, BAV)
• Anaesthesia, surgery and the heart
• Diseases of the great vessels and peripheral vessels

Vascular disease
• Peripheral arterial disease
  o Atherosclerosis
  o Arteritis
  o Aneurysmal disease
  o Dissection
• Cerebrovascular disease
  o TIA
  o Stroke
• Venous disease
  o DVT
  o Superficial thrombophlebitis
  o Venous incompetence
  o Post-thrombotic leg syndrome

Respiratory diseases and sleep disorders
• Pathophysiology of obstructive and restrictive respiratory disorders and of sleep-related breathing problems
• Main preventative strategies for obstructive lung disease and OSA
• Clinical presentation, diagnosis, evaluation and management of disease
  o Obstructive lung disease, including asthma, COPD
  o Obstructive and central sleep apnoea
  o Lung cancer
  o Pneumonia
  o Pulmonary embolus
  o Restrictive lung disease, including systemic diseases with an impact on the respiratory system (e.g. rheumatoid arthritis (RA)
  o Type 2 respiratory failure
• Overview of occupational and environmental lung disorders, disorders of the pleura and mediastinum and of cystic fibrosis, bronchiectasis and HIV/AIDS, genetic and developmental lung disorders, impact of cytotoxic and other drugs on respiratory system, pulmonary vascular diseases and connective tissue disorders
• Co morbidity and lung disease, e.g. COPD and heart failure
• Respiratory assessment and fitness for anaesthesia and surgery

Rotation F
Device Risk Management and Governance
[10 credits]
Role of hospital at home schemes/early discharge for exacerbations of COPD, home oxygen service.

The overall aim of this module is to provide trainees with the knowledge that underpins the rotation in Device Risk Management and Governance applied to the Critical Care environment.

**Learning Outcomes: Knowledge and Understanding**

On successful completion of this module the trainee will:

1. Work safely within the critical care and wider clinical environments.
2. Understand the basis of medical electronics and the medical device lifecycle.
3. Have the underpinning knowledge to gain useful practical experience within the context of the work based rotations.

**Learning Outcomes: Associated Work Based Learning**

High-level description of the work based learning that accompanies this academic module. Further details of the work based programme can be found in the Work Based Learning Guide, including the Clinical Experiential Learning, Competences and Applied Knowledge and Understanding.

On successful completion of this module the trainee will:

1. Operate a wide range of medical devices used in the clinical environment, understanding their clinical applicability, associated risks and limitations.
2. Operate standard workshop test equipment, specialist medical device test instrumentation, including electromedical safety testers. Use appropriate equipment to test a range of Class 1 and Class 2 equipment of types B, BF and CF, including some with applied parts.
3. Carry out the following device life-cycle technical tasks:
   - identify the key elements involved in medical device procurement
   - acceptance test and commission a new medical device
   - design training material to support the use of a medical device in the clinical setting
   - perform planned maintenance on a range of medical devices
   - observe the device repair process
   - condemn a medical device.
4. Identify sources of patient safety information and describe the key elements of processes to manage safety alerts and investigate patient incidents involving medical devices.
5. Identify and navigate the standards that underpin the organisation’s strategy for medical device management and service delivery arrangements for life-cycle management, including:
   - prevailing national standards for healthcare
   - legal/statutory requirements
   - electromedical safety standards
   - quality management standards
• risk management standards
• best practice standards
• organisational polices, and procedures, together with medical device workshop-specific procedures.

6. Use the organisation’s medical device information system for device risk management activities, including the recording of key information relating to life-cycle service elements as well as the ability to retrieve essential asset-related information and reports.

7. Perform a risk assessment on a piece of equipment or a service-related issue, showing an appreciation of local institutional risk management policies and procedures.

Safety
• Health and safety legislation specific to critical care technology
• Risk assessment techniques
• Chemical safety: COSHH, hazards, storage, use and disposal
• Electrical safety: medical equipment, leakage currents, fault conditions, isolation and circuit protection; biological/physiological response to electric shock; treatment of electric shock; equipment testing
• Mechanical safety: lifting gear; guards and operation of machine and hand tools, eye and ear protection; fumes, dusts, moving and handling
• Biological safety: pathological and normal specimens; blood and other tissues; equipment contamination, cleaning, cross-contamination; handling procedures and protocols
• Theatre safety: anaesthetic agents, explosion hazard, waste gas extraction, function checks, obstacles, sterility

Medical device life cycle
• Health technology assessment
• Principles of project management
• Quality systems and standards
  o ISO9000
  o EN13485
• Equipment evaluation
• Medical device life cycle
• Medical Devices Directorate
• Risk management principles applied to medical devices
## Section 12: MSc Clinical Science Specialist Modules for Cardiac Science

<table>
<thead>
<tr>
<th>Year</th>
<th>Core Modules</th>
<th>Specialist Modules</th>
<th>Module Titles</th>
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<tbody>
<tr>
<td><strong>Year 1</strong></td>
<td><strong>Core Modules</strong></td>
<td><strong>Specialist Modules</strong></td>
<td><strong>Module Titles</strong></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Ultrasound Imaging in Cardiac Disease or Diagnosis and Management of Cardiac Rhythm Disorders</td>
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<tr>
<td></td>
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<td></td>
<td>Research Project in Cardiac Science</td>
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<td></td>
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<td>Diagnostic approaches and current treatment of cardiovascular disorders</td>
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<td></td>
<td>Research Project in Cardiac Science</td>
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<tr>
<td></td>
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<td></td>
<td>Introduction to Healthcare Science, Professional Practice and Clinical Leadership</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Introduction to Cardiac, Vascular, Respiratory and Sleep Science Underpinning knowledge for rotational elements and integrated professional practice</td>
</tr>
</tbody>
</table>

**Generic Modules:** Common to all divisions of healthcare science

**Division/Theme-Specific Modules:** Common to a division or theme

**Specialist Modules:** Specific to a specialism
This module provides trainees with the knowledge that underpins the specialist modules in Cardiology and gives trainees the tools to undertake project based learning in the workplace. This module has three sections, which include: non-invasive diagnostics, invasive diagnostics and therapeutic interventions.

### Non-invasive Diagnostics (DA&CTCVSD-5(i))

**Learning Outcomes: Knowledge and Understanding**

On successful completion of this module the trainee will:

1. Evaluate the role of cardiac investigations in the choice of diagnostic and treatment options related to patient presentation and care pathways.
2. Describe the pathophysiology and co-morbidities associated with heart disease applying knowledge of normal anatomy and physiology.
3. Describe the haemodynamic and ECG response to exercise and posture, both normal and abnormal.

**Exercise Tolerance Testing, Cardiopulmonary Exercise Tests and Tilt Table Testing**

4. Justify the life-support requirements and evaluate the protocols for the management of peri-arrest, respiratory and cardiac arrest associated with each technique in accordance with Resuscitation Council guidance.
5. Discuss and appraise the environmental requirements, pharmacological influences, equipment, protocols, calibration, indications, contraindications and end-points in relation to local and national guidelines for each technique.
6. Discuss accurate data interpretation, analysis and report construction and management of results.
7. Critically evaluate the need to convey complex scientific information to inform multidisciplinary teams of the diagnostic results, conclusions and consequences, in clear reports, in a clinically appropriate time frame.

**Cardiac Ultrasound**

8. Describe the physics underlying the generation, propagation and detection of ultrasound waves in tissue and the application of Doppler and their clinical implications.
9. Critically appraise the technological principles involved in a diagnostic
ultrasound scanner and their implications, including safety for cardiac imaging.

10. Explain the limitations and artefacts of ultrasound and Doppler in cardiac imaging.

11. Describe the features of a normal cardiac ultrasound scan.

12. Discuss the advanced, complementary techniques to include cardiac CT, MRI and cardiac nuclide imaging.

<table>
<thead>
<tr>
<th>Learning Outcomes: Associated Work Based Learning</th>
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</thead>
<tbody>
<tr>
<td>High-level description of the work based learning that accompanies this academic module. Further details of the work based programme can be found in the Work Based Learning Guide, including the Clinical Experiential Learning, Competences and Applied Knowledge and Understanding.</td>
</tr>
</tbody>
</table>

On successful completion of this module the trainee will:

1. Plan, prepare and undertake a standard transthoracic echocardiogram in a patient with a structurally normal heart.
2. Under supervision, technically interpret the data and produce high-quality reports with respect to echocardiography, and be able to differentiate between artefact and physiological occurrence.
3. Plan, prepare and undertake a range of provocative electrocardiography procedures, in accordance with national guidelines.
4. Under supervision, technically interpret the data and produce high-quality reports with respect to non-invasive provocative electrocardiography, and be able to differentiate between artefact and physiological occurrence.
5. Carry out routine maintenance on equipment used for echocardiography and provocative electrocardiography procedures.

<table>
<thead>
<tr>
<th>Indicative Content</th>
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</thead>
<tbody>
<tr>
<td><strong>Anatomy and physiology</strong></td>
</tr>
<tr>
<td>• Anatomy and physiology of the cardiovascular system</td>
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<tr>
<td>• Coronary circulation</td>
</tr>
<tr>
<td>• Anatomy of the thorax related to ultrasound imaging</td>
</tr>
<tr>
<td>• Cardiac cycle</td>
</tr>
<tr>
<td>• Normal and abnormal haemodynamic and ECG response to exercise</td>
</tr>
<tr>
<td>• Overview of pathophysiology of acquired, congenital and ischaemic heart disease</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Exercise tolerance/Cardiopulmonary exercise testing</strong></th>
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</thead>
<tbody>
<tr>
<td>• History taking and gaining informed consent</td>
</tr>
<tr>
<td>• Indications, contraindications and end-points for exercise tolerance testing (ETT)/cardiopulmonary exercise testing (CPx)</td>
</tr>
<tr>
<td>• Differences between and indications for physiologist and physician-led testing</td>
</tr>
</tbody>
</table>

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Pharmacology related to provocative testing
Environmental requirements for ETT/CPx equipment characteristics, functions, use and care
Protocols and methods of exercise and their application
Recording of ECG and blood pressure
National and local guidelines, policies and procedures
Normal responses to exercise and ECG findings
Physiological, BP and ECG findings associated with outcome quantification
Interpretation, presentation and reporting of results
Management of results
Impact of results on patient care pathway
Calibration of CPx equipment

Tilt table testing
History taking and gaining informed consent
Pharmacology related to tilt table testing (TTT)
Environmental requirements for TTT equipment characteristics, functions, use and care
Indications, contraindications and end-points for TTT
Protocols for TTT
National and local guidelines, policies and procedures
Normal physiological BP and ECG findings
Recording of ECG and blood pressure
Physiological, BP and ECG findings associated with outcome quantification
Interpretation, presentation and reporting of results
Management of results
Impact of results on patient care pathway

Ultrasound physics
Basic principles and physics of ultrasound, spectral Doppler and colour flow Doppler
Application of these principles to cardiac imaging
Instrumentation associated with 2D, 3D, spectral Doppler, colour flow Doppler
Near and far fields; amplitude, intensity; power and frequency
Velocity, elasticity and density; acoustic impedance. Attenuation in tissue with reference to reflection, refraction, scattering and absorption. Dynamic range concept
Specular reflection, curved and irregular surfaces
Focusing using lenses
Speed of sound in soft tissue: 1540 ms⁻¹ and its significance
Range determination
Recording methods: choices, advantages and disadvantages

Storage and display of images
Basic concept of digital acquisition and system systems
Scan converters and digital memories
Display devices and controls and recording techniques
Transducers
- Piezo-electric effect
- Concepts of 2D and 3D transducer construction
- Characteristics of the ultrasound beam
- Beam steering methods
- Focusing methods and the use of dual focus
- The role of intracardiac echocardiography

Image optimisation
- Use of gel, to include infection risk from transducer and operator
- Positioning of the patient
- Standard views
- Use of non-standard views
- Adapting procedure where necessary

Knowledge of evolving technologies
- Deformation analysis
- Quantification of myocardial strain and strain rate by tissue Doppler
- Speckle tracking echocardiography/2D strain

Cardiac function parameters
- Measurements and calculations
- Doppler determination of cardiac haemodynamics
- Overview of a range of advanced techniques used in the diagnosis of cardiovascular and related diseases

Invasive Diagnostics (DA&CTCVSD-5(ii))

Learning Outcomes: Knowledge and Understanding
On successful completion of this module the trainee will:

Cardiac Catheterisation
1. Evaluate the role of cardiac investigations in the choice of diagnostic and treatment options related to patient presentation and care pathways.
2. Apply knowledge of cardiovascular anatomy and physiology to the recognition of co-morbidities and the influence of these on cardiac disease processes.
3. Describe the anatomy and pathophysiology of common congenital cardiac disorders.
4. Discuss the development of ischaemic heart disease and its associated risk factors.
5. Discuss coronary artery influences on cardiac rhythm.
6. Discuss the indications for, limitations and risks of cardiac catheterisation.
7. Describe the normal pressure waveforms, normal ranges and recognise abnormal recordings.
8. Discuss the measurement of cardiac output, both by direct and estimated techniques and evaluate techniques used to measure oxygen saturation.
9. Describe the use, function and characteristics of pressure amplifiers, catheters, consumables, various transducers and factors that influence the quality of pressure waveform.
10. Describe venous and arterial access techniques, indications, contraindications and complications.
11. Recognise normal and abnormal oxygen saturations and relate these to common abnormalities.
12. Discuss the different modalities used during cardiac catheterisation for the assessment of coronary artery patency, such as intravascular ultrasound (IVUS) and pressure wire calculation.
13. Discuss the implications of clinical findings at cardiac catheterisation and its influence on patient care pathway.
14. Discuss the indications for and limitations of implantable loop recording (ILR).
15. Describe the techniques for optimal ILR recording and management of patients with implanted loop recorders.
16. Demonstrate knowledge and understanding of sensing algorithms and parameters for arrhythmia storage.
17. Discuss the concepts of ILR device implantation procedure and related complications.

Learning Outcomes: Associated Work Based Learning

High-level description of the work based learning that accompanies this academic module. Further details of the work based programme can be found in the Work Based Learning Guide, including the Clinical Experiential Learning, Competences and Applied Knowledge and Understanding.

On successful completion of this module the trainee will:

1. Plan, prepare and set up for left heart catheterisation and provide scientific support and analysis.
2. Plan, prepare and set up for right heart catheterisation and provide scientific support and analysis.
3. Plan, prepare and set up for left and right heart catheterisation and provide scientific support and analysis.
4. Troubleshoot problems with the monitoring system and, where appropriate, carry out routine maintenance procedures on the equipment used for cardiac catheterisation.
5. Plan, prepare and set up for implantable loop recorder (ILR) insertion, and manage post-implantation follow-up.

Note: The trainee should produce evidence of completion of immediate or advanced life support training before undertaking any of the learning outcomes.

Indicative Content
Cardiac catheterisation

- MRSA screening and pre-assessment for cardiac catheterisation procedures
- Detailed anatomy and physiology of the cardiovascular system
- Pathophysiology related to cardiac catheterisation
- Overview of common congenital heart disease
- Development of ischaemic and valvular heart disease and associated risk factors
- Influence of coronary artery anatomy and patency on cardiac rhythm
- Implications of findings from cardiac catheterisation and the effect on patient care pathway
- Indications, contraindications, limitations and risk factors associated with the procedure
- Importance of ECG, blood pressure and O2 saturation monitoring during the procedure
- ECG abnormalities and required interventions
- Normal pressure waveforms and normal value ranges
- Abnormal recordings and associated pathology
- Measurement of cardiac output by thermodilution and Fick principle
- Haemodynamic measurements made during cardiac catheterisation
- Characteristics and functions of transducers, pressure amplifiers
- The influence of equipment and consumable characteristics on the quality of pressure recordings
- Techniques for venous and arterial access, indications, risks and complications
- Characteristics and use of catheters and connecting tubing
- Oxygen saturation measurement techniques and application
- Recognition of normal and abnormal oxygen saturation measurements and their relationship to common abnormalities
- Different modalities used for the quantification analysis of disease progression and coronary artery lesions to include intravascular ultrasound (IVUS) and pressure wires
- Immediate/Advanced life support in line with Resuscitation Council UK
- Production and structure of findings and storage of results

Implantable loop recorders

- MRSA screening and pre-assessment for ILR implantation
- Indications for and contraindications to use of ILR
- Benefits and limitations of ILR
- Characteristics and functions of ILR
- Implant techniques for ILRs
- Electrogram characteristics and device positioning for optimal ILR electrogram recording
- Implant measurements and observations
- Patient management pre-implant, during the procedure and post implantation
- Monitoring of BP, ECG and O2 saturations during implantation of ILRs
- Management of patients before, during and after implant of ILRs
Therapeutic Interventions (DA&CTCVSD-5(iii))

Learning Outcomes: Knowledge and Understanding

On successful completion of this module the trainee will:

1. Critically evaluate the role of cardiac investigations in the choice of diagnostic and treatment options related to patient presentation and care pathways.
2. Apply knowledge of anatomy and physiology, including myocardial/cell electrophysiology and coronary artery influence to normal and abnormal cardiac rhythms.
3. Discuss the importance of the clinical history, clinical examination and investigation prior to invasive cardiac therapeutic investigations.
4. Critically appraise the optimal care pathway for the patient’s therapeutic intervention based on their symptoms, physiology, co-morbidities and risk factors.
5. Critically appraise the range of X-ray and aseptic techniques related to invasive cardiac procedures and differentiate between a normal and abnormal chest X-ray for common cardiac presentations.

Implantable Devices
6. Discuss the clinical conditions and ECG indicators for temporary and permanent pacing.
7. Describe the characteristics, function and application of temporary pacing.
8. Discuss the fundamental physical principles of implantable cardiac device systems technology, design and construction, and the American Heart Association and European Standard Identification guidelines and databases.
9. Compare and contrast a range of rhythm management devices, including the use of timing cycles, rate modulation, sensing, stimulation and algorithms.
10. Discuss the concepts of cardiac pacing device implantation procedures and range of measurements taken at implant, and state the normal values and relate deviations from normal ranges to clinical physiology.
11. Describe the principles underpinning algorithms for bradycardia pacing systems and evaluate a range of product-specific pacing algorithms.

Percutaneous coronary interventions (PCI)
12. Discuss the indications, contraindications, types, risks and benefits of PCI and the parameters that need to be monitored during PCI.
13. Evaluate the role of pre-assessment of the PCI patient, including MRSA screening.
14. Discuss the application of cardiac catheterisation in PCI and pressure waveform behaviours during PCI and their physiological and clinical implication.
15. Discuss the use, indications, contra-indications, benefits and complications associated with the use of intra-aortic balloon pump therapy and the alternative therapies available.

**Pharmacology and Prescribing**

16. Explain the principles of pharmacology, pharmacokinetics and therapeutics, including therapeutic classes of cardiac drugs.

17. Discuss the mode of action, indications, contraindications and side effects of commonly used pharmacological treatments.

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**Learning Outcomes: Associated Work Based Learning**

High-level description of the work based learning that accompanies this academic module. Further details of the work based programme can be found in the Work Based Learning Guide, including the Clinical Experiential Learning, Competences and Applied Knowledge and Understanding.

On successful completion of this module the trainee will:

1. Plan, prepare, set up and undertake cardiac physiological role for percutaneous coronary intervention (PCI).
2. Plan, prepare, set up and undertake cardiac physiological role for intra-aortic balloon pump (IABP).
3. Plan, prepare, set up and undertake cardiac physiological role for rotablation.
4. Plan, prepare, set up and undertake cardiac physiological role for flow wire.
5. Plan, prepare, set up and undertake cardiac physiological role for intravascular ultrasound (IVUS).
6. Undertake cardiac physiological role in providing effective physiological/technical and scientific support and expertise for brady pacemaker implantation and temporary pacemaker insertion
7. Manage post-brady pacemaker implantation follow-up.

**Note:** The trainee should produce evidence of completion of immediate or advanced life support training before undertaking any of the learning outcomes.

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**Indicative Content**

**Rhythm management devices**

- Normal cardiac conduction system and its relationship with the ECG
- Abnormal cardiac conduction and ECG manifestations
- The development of ischaemic heart disease and associated risk factors
- NICE guidelines for device implantation
- Procedural differences between adult and paediatric device implantation
- Initial diagnostic assessment and symptom history
• Clinical indications for device implantation, including national guidelines and classifications
• Device selection related to patient physiological needs
• Complications associated with anatomical anomalies and device implantation
• Conscious sedation, intravenous sedation, analgesia in the lab setting
• ILS/ALS in line with the Resuscitation Council UK
• Asepsis techniques
• Implantation procedure: Seldinger technique, cephalic/subclavian access
• Hardware selection criteria: device and leads
• Identify normal positions of leads on X-ray and fluoroscopy

Measurements at implantation, including normal ranges
• Battery voltage
• Pacing threshold
• Lead impedance
• Current drain
• Sensing threshold
• Slew rate

Sensing
• Cardiac signals, A/V/T wave/injury currents/pericardial signals
• Principles of undersensing, oversensing and sensitivity
• Relationship between sensing and programmed sensitivity
• Adjustment of the sensitivity for accurate sensing.
• Intracardiac signals of basic electrophysiology

Capture thresholds
• Role of capture threshold in the implantation process
• Identify capture and loss of capture
• Measurement of the output threshold
• Adjust the capture output in line with the threshold with an appropriate safety margin
• Familiarity of the hardware used for the implantation for pacemakers (single/dual/CRT)
• Troubleshooting implantation complications

Types of emergency temporary pacemaker characteristics
• Percussion
• Trans-thoracic external
• Endocardial
• Epicardial
• Oesophageal

Adjustment/programming of temporary pacemakers
• Output
• Sensitivity
• Mode
Potential problems with temporary pacemakers
- Oversensing
- Undersensing
- Interactions with permanent implanted devices
- Infection risk
- Loss of capture and output adjustment, including amplitude and pulse duration

Chronological development of implantable devices
- Dates of first implants
- Unipolar/bipolar
- Epicardial system – patches/sense pace leads/abdominal implant
- Endocardial – tunneled lead/abdominal implant
- Endocardial – single pass lead/pectoral implant

Construction and interaction of different types of pacemaker lead and header connectors
- Unipolar/bipolar
- Types of connector
- Hex wrench sizing
- Connectivity between lead and header

Algorithms
Principles behind bradycardia algorithms
- Mode switching
- Pacemaker mediated tachycardia algorithms
- Noise response
- Rate smoothing

Product-specific algorithms allowing mode switching
Product-specific discriminating algorithms in current devices

Battery technology
- Pacemaker battery chemical composition and depletion characteristics
- Battery impedance, voltage, battery charge
- Elective replacement indicators

Function and connection of circuitry components
- Band pass filtering – intracardiac intracardiac electrograms (EGM) frequency
- Input and output amplifiers

Rate response technology
- Types of sensor multisensor pacemakers

Physics related to pacing technology
- Ohms law: energy calculation, power, resistance and slew rate
- Measurements related to optimal settings

Normal parameter changes over time
• First week
• First three months
• Lead/device lifetime

**Lead hardware problems**
• Fracture
• Insulation break
• Perforation
• Poor header connection
• Leads reversed in header

**Device hardware problems**
• Header connection
• Deformation of can

**Assessment of implanted system in order to ascertain potential problems**
• Provocative manoeuvres
• EMI
• Lead impedance, pacing and sensing threshold
• Oversensing
• Undersensing
• Upper rate behaviour
• Inappropriate ICD detection and therapy
• EGM assessment and understanding

**Theoretical and practical aspects of pulse generator technology**
• Theory of pulse generator technology
• Theoretical aspects and application of the technology related to underlying physical conditions
• Anatomical placement and locations of pulse generators
• Identification of pulse generator components
• Principles of pulse generator interrogation

**American Heart Association and European Standard Identification**
• Use of pulse generator modes
• Use of pulse generator codes
• Appropriate use of the mode/code criteria relating to underlying medical conditions

**Materials used in the construction of pulse generator leads**
• Knowledge of different types of lead insulation
• Significance of type of lead insulation
• Lead fixation technology and implications
• Lead length related to patient size
• Lead construction and element separation

**Pulse generator lead connection**
• Types of connector
• Appropriate use and application of adaptors
• Implications of incorrect lead connections
• Practical implications of single vs dual electrode technology
• Practical implications of unipolar vs bipolar electrode technology
• Surface material/surface structure
• Electrode materials
• Spacing implications

Use of single chamber devices
• Appropriate use of single chamber devices
• Underlying medical conditions
• Long-term implications

Use of dual chamber devices
• Appropriate use of dual chamber devices
• Underlying medical conditions
• Long-term implication

Use of timing cycles
• Relationship between mechanical and physiological timing cycles
• Relative and absolute refractory
• Blanking period
• Atrial-based timing vs ventricular-based timing
• Mechanical timing limitations

Rate modulation
• Rate response mechanisms within pulse generators
• Technology of rate response sensors
• Implications of single vs dual sensors
• Rate smoothing algorithms
• Limitations of rate modulation

Differences between pulse generator technologies
• Use, application and limitation of pacemakers
• Use, application and limitation of ICDs
• Use, application and limitation of CRT devices
• Combined technology

Stimulation
• Anode/cathode stimulation
• Stimulation/defibrillation threshold
• Ohm’s law; current, voltage and impedance (calculation of)
• Strength duration; stimulation threshold. Rheobase and chronaxie time
• Power and energy

Timing cycles
• Single chamber
• Dual chamber – atrial based and ventricular based
• Rate modulation – rate responsive AV delay and post ventricular atrial refractory period (PVARP)
• CRT (bivent) V-V timing
Review of chest X-ray post device implant
• Pneumothorax
• Haemothorax
• Lead position/displacement

Percutaneous coronary interventions (PCI)
• Anatomy and physiology of the coronary circulation
• Development of ischaemic heart disease and associated risk factors
• Application of cardiac catheterisation to PCI
• Types of coronary intervention and indications for
• Risks and complications associated with coronary intervention
• Management of risks and complications associated with PCI
• Influence of coronary arteries on cardiac rhythm
• Identification and evaluation of coronary lesions
• Choice, design, construction, application and use of guide wires, balloon catheters and stents
• Techniques for the introduction of catheters, etc.
• Angioplasty and stenting techniques and equipment
• Role of pressure measurement during procedures

Pharmacology and prescribing (in context of cardiovascular disease)
• Major classes of cardiac drugs
• Mode of actions
• Indications
• Contraindications
• Clinical uses and applications
• Significant side effects
• Interactions
• Anti-arrhythmic agents
• Class I – sodium channel blockers (a, b, c)
• Class II – beta blockers
• Class III – potassium channel blockers
• Class IV – calcium channel blockers
• Cardioinhibitory
• Cardiostimulatory
• Diuretic
• Anti-hypertension
• Thrombolytic agents
• Vasoconstrictor
• Vasodilator
• Anti-hyperlipidemic agents
• Miscellaneous, e.g. ivabradine, ranolazine

Division: Physiological Sciences
Theme: Cardiac, Critical Care, Vascular, Respiratory and Sleep, Gastrointestinal Physiology and Urodynamic Sciences
Specialism: Cardiac Science
Years 2 and 3: Research Project
The overall aim of this module, building on the Research Methods module, is for the trainee to undertake a research project that shows originality in the application of knowledge, together with a practical understanding of how established techniques of research and enquiry are used to create and interpret knowledge in a specialism of healthcare science. The research project may span scientific or clinical research, translational research, operational and policy research, clinical education research, innovation, service development, service improvement, or supporting professional service users to meet the expected learning outcomes. Research projects should be designed to take into account the research training required by individual trainees and the needs of the department in which the research is to be conducted.

### Learning Outcomes: Knowledge and Understanding

On successful completion of this module the trainee will:

1. Discuss the stages of the research and innovation process from conceptualisation to dissemination and, if appropriate, translation into practice.
2. Describe the purpose and importance of different kinds of research, including scientific or clinical research, translational research, operational and policy research, clinical education research, innovation, service development, service improvement and supporting professional service users, and relate these to the roles undertaken by Clinical Scientists in the trainee’s specialism.
3. Discuss and evaluate the use of reference manager systems.
4. Justify the rationale for research governance and ethical frameworks when undertaking research or innovation in the NHS.
5. Describe the process and requirements for publication in a peer-reviewed journal and the current system of grading research publications.

### Learning Outcomes: Practical Skills

On successful completion of this module the trainee will:

1. Design, plan and undertake a research project to test a hypothesis from conception to completion/archiving in accordance with ethical and research governance regulations, drawing on expert advice where necessary and involving patients and service users.
2. Analyse the data using appropriate methods and statistical techniques, and interpret, critically discuss and draw conclusions from the data.
3. Prepare a written project that describes and critically evaluates the research project, clearly identifying the strengths and weaknesses.
4. Present a summary of the research project and outcome that conforms to the format of a typical scientific presentation at a national or international scientific meeting, responding to questions appropriately.
5. Prepare a summary of the research project suitable for non-specialist and lay audiences.

**Indicative Content**
- Critical evaluation of the literature/evidence base
- Reference management
- Identification of a research question
- Research ethics and regulatory requirements, including issues related to access and use of information
- Data protection and confidentiality guidelines
- Patient safety
- Patient consent
- Sources of funding/grants
- Peer review/expert advice
- Possible risks and balancing risk vs benefit
- Project management techniques and tools
- Roles and responsibilities of those involved in the research
- Monitoring and reporting
- Data analysis
- Data interpretation
- Criteria/metric for assessing and grading research data and publications in the scientific, NHS and HE sectors
- Range of formats and modes of presentation of data
- Requirements for publications submitted to scientific, education and similar journals
- Current conventions with respect to bibliography and referencing of information

**Section 12.1 Specialist Route: Ultrasound Imaging in Cardiac Disease**

In Year 3, trainees will undertake one of two specialist options, namely Ultrasound Imaging in Cardiac Disease or Diagnosis and Management of Cardiac Rhythm Disorders.

<table>
<thead>
<tr>
<th>Division:</th>
<th>Physiological Sciences</th>
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<tbody>
<tr>
<td>Theme:</td>
<td>Cardiac, Critical Care, Vascular, Respiratory and Sleep</td>
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<tr>
<td>Specialism:</td>
<td>Cardiac Science</td>
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<tr>
<td>Specialist route:</td>
<td>Ultrasound Imaging in Cardiac Disease</td>
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<tr>
<td>Year 3:</td>
<td>Ultrasound Imaging in Cardiac Disease (UICD-6)</td>
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<td>[30 credits]</td>
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This module provides trainees with the knowledge that underpins the third year specialist module in Cardiology, undertaking the Ultrasound route, and gives trainees the tools to undertake learning in the workplace.

**Learning Outcomes: Knowledge and Understanding**

On successful completion of this module the trainee will:
1. Describe the coronary anatomy and its correlation with 2D views of the left ventricle.
2. Describe and evaluate methods used to measure and evaluate left ventricular function and recognise normal and abnormal ventricular function.
3. Describe normal Doppler mitral valve filling patterns and normal ranges.
4. Recognise the appearance of complications after myocardial infarction.
5. Discuss the echocardiographic features and assessment methods associated with cardiomyopathies, valvular disease and ventricular dysfunction and the relationship to surgical treatments.
6. Discuss the pathology, causes and echocardiographic features associated with right ventricular dysfunction and pulmonary hypertension; endocarditis and the Duke criteria for diagnosing endocarditis; pericardial disease, cardiac masses, suspected acute pulmonary embolus and blunt/penetrating cardiac trauma.
7. Discuss the types of valve replacement, criteria of normality and signs of failure.
8. Describe the echocardiographic findings typically occurring in association with a hypotensive/shocked patient and post cardiac arrest.
10. Evaluate and justify the criteria for the use of transoesophageal echocardiography.

Learning Outcomes: Associated Work Based Learning

High-level description of the work based learning that accompanies this academic module. Further details of the work based programme can be found in the Work Based Learning Guide, including the Clinical Experiential Learning, Competences and Applied Knowledge and Understanding.

On successful completion of this module the trainee will:

1. Perform transthoracic echocardiographic examination to assess the size and function of the left ventricle.
2. Perform transthoracic echocardiographic examinations on patients with suspected mitral valve disease.
3. Perform transthoracic echocardiographic examinations on patients with suspected aortic valve disease.
4. Perform transthoracic echocardiographic examination to assess the size and function of the right ventricle.
5. Perform transthoracic echocardiographic examinations on patients with suspected infective endocarditis, pericardial effusion and cardiac masses.
6. Perform transthoracic echocardiographic examinations on adult patients with congenital heart disease.
7. Perform an appropriate transthoracic echocardiographic study in a critically unwell patient and identify any significant clinical findings.
8. Make appropriate measurements and interpret the ultrasound data, and produce high-quality reports.
Critically appraise current literature/research studies for general cardiac ultrasound and related topics, incorporating evidence-based practice.

Note: The trainee should produce evidence of completion of immediate or advanced life support training before undertaking any of the learning outcomes.

Indicative Content
- Anatomy and physiology of the cardiovascular system with particular reference to coronary anatomy
- Measurement and evaluation of left ventricular function using echocardiography
- Normal Doppler mitral valve filling patterns

Pathophysiology
- Review of cardiovascular anatomy and physiology
- Aetiology and echocardiographic features of cardiovascular pathophysiological conditions
- Recognition and evaluation of cardiovascular disorders using cardiac ultrasound and Doppler imaging

Conditions
- Mitral stenosis and regurgitation
- Aortic stenosis and regurgitation
- Diseases of the aorta
- Tricuspid stenosis and regurgitation
- Pulmonary valve disease
- Pulmonary hypertension
- Infective endocarditis
- Intracardiac masses
- Cardiomyopathies
- Pericardial diseases
- Coronary artery disease and LV function
- Myocardial infarction and its sequelaes
- LV dyssynchrony
- Overview of congenital heart disease

Emergency and ICU echocardiography
- Environmental issues
- Clinical findings
- Constraints

Role of exercise echocardiography in assessing patients for surgery/balloon valvoplasty

Role of transesophageal echocardiography (TOE) in assessing valvular pathology to determine type of intervention
Role of echocardiography in the evaluation of effective function and dysfunction of prosthetic heart valves
Section 12.2: Specialist Route: Diagnosis and Management of Cardiac Rhythm Disorders

**Division:** Physiological Sciences  
**Theme:** Cardiac, Critical Care, Vascular, Respiratory and Sleep Sciences  
**Specialism:** Cardiac Science  
**Specialist Route:** Diagnosis and Management of Cardiac Rhythm Disorders

In Year 3, trainees will undertake **two** specialist MSc modules in Cardiac Rhythm Management: Electrophysiology and Arrhythmia Management, and Patient and Device Follow-Up. Note: There is a single accompanying work based module ‘Diagnosis and Management of Cardiac Rhythm Disorders – Arrhythmia Management and Patient Follow-Up’

**Electrophysiology and Arrhythmia Management  
[25 credits]**

This module provides trainees with the knowledge that underpins the third year specialist module in Cardiac Rhythm Management. It will provide trainees with the knowledge, understanding and practical skills to safely contribute to the diagnosis and treatment of patients with abnormalities of cardiac rhythm and provides the knowledge that will underpin learning in the work base.

**Learning Outcomes: Knowledge and Understanding**

On successful completion of this module the trainee will:

1. Recall the anatomy and physiology of the heart and explain, in depth, the anatomy and physiology of the heart relevant to cardiac rhythm management.
2. Describe the mechanisms of arrhythmia generation.
3. Explain the indications for device implantation and placement and the evidence-based current guidelines.
4. Describe the cardiac physical examination, including auscultation, measurement of jugular venous pressure and blood pressure.
5. Recognise ECG changes associated with inherited arrhythmia syndromes, channelopathies/Brugada syndrome, long QT and short QT.
6. Describe the underpinning physics of the instrumentation/equipment used in electrophysiology studies, including the functionality of amplifiers.
7. Identify implanted devices and lead systems from a chest X-ray
8. Describe programming possibilities for atrial arrhythmia suppression.
9. Describe product specific algorithms for atrial anti-tachycardia pacing.
10. Explain the principles behind tachycardia detection and redetection.
11. Explain the definitions and terminology of tachycardia discrimination software.
12. Describe the hardware used in ICD implantation.
Indicative Content

**High energy shock leads**
- Electrodes
- Different types of lead insulation
- Single and dual coil electrodes
- Subcutaneous array lead
- Multilumen vs conventional coaxial design
- Connectors

**Use of CRT devices**
- Appropriate use of CRT devices
- Underlying medical conditions
- Long-term implication

**Use of timing cycles**
- Relationship between mechanical and physiological timing cycles
- Relative and absolute refractory
- Blanking period
- Atrial-based timing vs ventricular-based timing
- V-V timing in CRT devices with relation to inter- and intraventricular delay
- Mechanical timing limitations

**Rate modulation**
- Rate response mechanisms within pulse generators
- Technology of rate response sensors
- Implications of single vs dual sensors
- Rate smoothing algorithms
- Limitations of rate modulation

**Sensing**
- Cardiac signals A/V/T wave/injury currents/pericardial signals
- Intracardiac signals of basic electrophysiology (EP)

**Stimulation**
- Anodal/cathodal stimulation
- Stimulation/defibrillation threshold
- Ohm’s law; current, voltage and impedance (calculation of)
- Strength duration; stimulation threshold. Rheobase and chronaxie time
- Power and energy

**Timing cycles**
- Single chamber
- Dual chamber – atrial based and ventricular based
- Rate modulation – rate responsive AV delay and PVARP
- CRT (bivent) V-V timing

**Algorithms**
- Bradycardia/tachycardia pacing therapy
• Tachycardia detection
• SVT discrimination
• ATP pacing

Hardware used in ICD implantation
• Seldinger technique
• Introducer sheaths
• LV lead introduction hardware
• Transeptal equipment
• Transeptal technique

Programming possibilities for atrial arrhythmia suppression
• Mechanism of action
• Rate stabilisation
• Automatic atrial rate increase algorithms
• Overdrive

Product-specific algorithms for atrial anti-tachycardia pacing
Individual company/product-specific algorithms

Principles behind tachycardia detection and redetection
Individual company/product-specific algorithms

Definitions and terminology of tachycardia discriminator software
• Stability
• Onset
• Morphology
• VT-ST boundary

Battery technology
• Pacemaker battery chemical composition and depletion characteristics
• ICD battery chemical composition and depletion characteristics
• Battery impedance, voltage, battery charge
• Elective replacement indicators

Function and connection of circuitry components
• Capacitors – structure and function
• Band pass filtering – intracardiac EGM frequency
• Sense amplifiers
• Output pulse square wave

Acceptable measurements at implant
• Battery voltage
• Pacing threshold
• Lead impedance
• Current drain
• Sensing threshold
• Slew rate

Normal parameter changes over time
• First week
• First three months
• Lead/device lifetime

**Lead hardware problems**
• Fracture
• Insulation break
• Perforation
• Poor header connection
• Leads reversed in header

**Device hardware problems**
• Header connection
• Deformation of can

**Assessment of implanted system to ascertain potential problems**
• Provocative manoeuvres
• EMI
• Lead impedance, pacing and sensing threshold
• Oversensing
• Undersensing
• Upper rate behaviour
• Inappropriate ICD detection and therapy
• EGM assessment

**Basic electrophysiology**
• Anatomy and physiology of the heart, to include detail of the conduction system
• Electrophysiological anatomy of the normal conduction system
• Electrophysiology of abnormal conduction, to include slow and fast pathways
• Baseline measurements of electrograms (AV, AH, VA, CL)
• Action potentials, gates and channels: channelopathies
• Differences of action potentials at differing anatomical locations
• Abnormalities of the conduction system: failure to initiate, failure to propagate

**Mechanisms of arrhythmia**
• Re-entry
• Triggered
• Automaticity
• Anisotropy
• Process of induction
• Arrhythmia behaviours
• Pacing mechanisms during arrhythmia to aid diagnosis
• Termination behaviours of arrhythmias

**Remote entry**
• Familiarisation with different remote monitoring applications
• Clinical use of remote monitoring applications
• Limitations of remote monitoring

**Clinical assessment**
- Indications for device therapy, placement, associated trials and NICE guidelines
- Brady arrhythmias
- Tachy arrhythmias
- Chronic congestive heart failure
- Syncope

**Basic pharmacology**
- Types of drugs commonly used in rhythm management
- Major cardiovascular responses; pharmacokinetics
- Drug effects on the action potentials
- Drug effects on cardiac rhythm and conduction

**Radiation associated with X-rays and fluoroscopy**
- Measurement of radiation for chest X-ray
- Measurement of radiation for fluoroscopy
- Radiation safety regulations
- Lateral/PA X-rays

**Recognition of devices using X-ray**
- Type of device from X-ray
- Identifying manufacturer from X-ray
- Type of lead
- Type of lead – ICD
- Site of implant

Normal positions of leads on X-ray and fluoroscopy.

RA – appendage/free wall

RV – septal/apical

LV – mid-lateral free wall

**Abnormal lead positions and lead problems**
- Displacement
- Perforation
- Fracture
- Pneumothorax
- Subclavian crush

**Anatomical landmarks from fluoroscopy**
- CS ostium
- CS venous anatomy
- MV/AV/TV
- AV ring
**EP catheter positions from fluoroscopy**
- RAO
- LAO
- Lateral
- AP

**Clinical electrophysiology**
- Initial assessment and diagnostic work-up
- Pre-assessment of patient
- MRSA screening
- ECG assessment
- Arrhythmia recognition
- Pacing stimulators
- Sensing/oversensing
- Outputs and thresholds
- Coupling intervals
- Risks associated with the procedure
- Different protocols for induction and overdrive pacing

**Clinical evaluation of arrhythmia**
- Response to drugs
- Response to vagal manoeuvres
- Emergency management

**Patient and Device Follow-Up**

| [5 credits] |

This module provides trainees with the knowledge that underpins the third year specialist module in Cardiac Rhythm Management. It will provide trainees with the knowledge, understanding and practical skills to safely contribute to the diagnosis and treatment of patients with abnormalities of cardiac rhythm and provides the knowledge that will underpin learning in the workplace.

**Learning Outcomes: Knowledge and Understanding**

On successful completion of this module the trainee will:

1. Explain the process of wound healing process.
2. Describe the clinical signs and symptoms associated with heart failure.
3. Describe the possible symptoms associated with tachy and brady arrhythmias.
4. Explain and justify the DVLA requirements for patients with abnormalities of cardiac rhythm.
5. Compare current guidelines with respect to cardiac rhythm management.

**Indicative Content**
Clinical signs and symptoms associated with heart failure
- Shortness of breath
- Increasing peripheral oedema
- Increased weight
- Decreased exercise tolerance
- Relationship between diagnostic data and devices
- Possible symptoms associated with tachy/brady arrhythmias

Communication with patients and carers
- Proactive verbal investigation of symptoms
- Careful listening to description of symptoms
- Organisation and explanation of further investigation if deemed necessary
- Core questions: evaluation of box site, dizziness, palpitations, breathlessness, timing and duration of any symptoms, chest pain

Guidelines including:
- Driver and Vehicle Licensing Agency (DVLA)
- Heart Rhythm United Kingdom (HRUK)
- American Heart Association (AHA)
- European Society of Cardiology (ESC)

Learning Outcomes: Associated Work Based Learning
High-level description of the work based learning that accompanies this academic module. Further details of the work based programme can be found in the Work Based Learning Guide, including the Clinical Experiential Learning, Competences and Applied Knowledge and Understanding.

On successful completion of this module the trainee will:
1. Perform and interpret procedures to assess implanted cardiac devices and, using appropriate algorithms, program and optimise the device to monitor or provide treatment appropriate to patients with single chamber bradycardia, recognising the clinical signs and symptoms of device complications.
2. Perform and interpret procedures to assess implanted cardiac devices and, using appropriate algorithms, program and optimise the device to monitor or provide treatment appropriate to patients with single chamber tachycardia, recognising the clinical signs and symptoms of device complications.
3. Perform and interpret procedures to assess implanted cardiac devices and, using appropriate algorithms, program and optimise the device to monitor or provide treatment appropriate to patients with dual chamber bradycardia, recognising the clinical signs and symptoms of device complications.
4. Perform and interpret procedures to assess implanted cardiac devices and, using appropriate algorithms, program and optimise the device to monitor or provide treatment appropriate to patients with dual chamber...
tachycardia, recognising the clinical signs and symptoms of device complications.

5. Perform and interpret procedures to assess implanted cardiac devices and, using appropriate algorithms, program and optimise the device to monitor or provide treatment appropriate to patients with CRT-P (cardiac resynchronization therapy with pacemaker function), recognising the clinical signs and symptoms of device complications.

6. Perform and interpret procedures to assess implanted cardiac devices and, using appropriate algorithms, program and optimise the device to monitor or provide treatment appropriate to patients with CRT-D (cardiac resynchronization therapy with defibrillator function), recognising the clinical signs and symptoms of device complications.

7. Perform long-term follow-up procedures for patients with implanted cardiac devices, ensuring the safe and effective functioning of each device and highlighting devices that may need replacement.

8. Critically appraise current literature/research studies that address the issues of the diagnosis and management of cardiac rhythm disorders, incorporating evidence-based practice.

**Note:** The trainee should produce evidence of completion of immediate or advanced life support training before undertaking any of the learning outcomes.
### Section 13: MSc Clinical Science Modules for Critical Care Science

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<td>Respiratory and Sleep Science 2</td>
<td>Introduction to Healthcare Science, Professional Practice and Clinical Leadership</td>
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<tr>
<td>Monitoring and Supporting Critically Ill Patients</td>
<td>Research Project in Critical Care Science</td>
<td>Underpinning knowledge for rotational elements and integrated professional practice</td>
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<tr>
<td>Diagnostic and Therapeutic Techniques In Critical Care</td>
<td>Research Project in Critical Care Science</td>
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**Module Titles**

- **Generic Modules**: Common to all divisions of healthcare science
- **Division/Theme-Specific Modules**: Common to a division or theme
- **Specialist Modules**: Specific to a specialism
MSc Year 2 Specialist Practice

Critical Care trainees will complete 20 CREDITS of learning from the Year 3 MSc Clinical Science module Respiratory and Sleep Science 2.

These modules provide the trainee with the knowledge and understanding that underpins and is applied to the specialist work based learning programme.

Division: Physiological Sciences
Theme: Cardiac, Critical Care, Vascular, Respiratory and Sleep, Sciences
Specialism: Critical Care Sciences
Year 2: Respiratory and Sleep Science 2
[20 credits]

Learning Outcomes: Knowledge and Understanding

On successful completion of this module the trainee will:

1. Describe blood gas physiology and acid-base balance.
2. Discuss the principles and role of short- and long-term oxygen therapy in the treatment of disease.
3. Describe the evidence base for oxygen prescription and assessment of patients for long-term oxygen therapy.
4. Describe the role of field exercise testing in the assessment for ambulatory oxygen.
5. Describe the process for ordering oxygen therapy.
6. Discuss the pathophysiology of common causes of respiratory failure.
7. Describe the role of non-invasive ventilation in the treatment of acute and chronic respiratory failure in a range of disorders, to include airway, chest wall and muscle disorders.
8. Discuss the range of ventilators available for the provision of non-invasive ventilation, their modes of action and functions.
9. Discuss the assessment and monitoring of patients receiving non-invasive ventilation in the acute and chronic setting.
10. Describe the structure, function, mechanics and control of the cardiorespiratory system, to include ventilation, gas transport and exchange, haemodynamics and cardiac output during rest and exercise.
11. Recognise the physiological adaptations that occur with exercise training.
12. Describes the range of exercise tests available and their clinical importance.
13. Describe the application of cardiopulmonary exercise testing in the assessment of limitations to exercise.
14. Describe the common protocols used in cardiopulmonary exercise testing.
15. Recognise the uses and limitations of cardiopulmonary exercise testing and its value in clinical practice.
16. Discuss the application of interpretation strategies to respiratory investigations.
Learning Outcomes: Associated Work Based Learning

High-level description of the work based learning that accompanies this academic module. Further details of the work based programme can be found in the Work Based Learning Guide, including the Clinical Experiential Learning, Competences and Applied Knowledge and Understanding.

On successful completion of this module the trainee will:

1. Perform and interpret assessments of blood gas status and identify the requirements for supplemental oxygen therapy.
2. Observe and assist during full cardiopulmonary exercise testing in the investigation of respiratory, vascular and cardiac disease.
3. Perform the selection the appropriate mode and pattern of ventilation with respect to the patient’s sedation level and lung pathology and pathophysiology.
4. Set and assist in the interpretation of data from ventilator alarms and the recognition and rectification of common problems associated with ventilator testing and application in a range of patients.
5. Perform routine non-invasive monitoring in a critical care setting and responds to trends in physiological variables.
6. Identify the requirement for and initiate non-invasive ventilation (NIV) in patients with both acute and chronic respiratory failure.
7. Discuss and agree ventilation and monitoring strategies for critically ill patients and demonstrate the communication skills required to discuss subjects that may be difficult.

Indicative Content

Anatomy and physiology

Cardiorespiratory responses to exercise
- Normal response to exercise, to include:
  - Muscles – structure, metabolism, substrates
  - Cardiac response to exercise – control of response, cardiac frequency and stroke volume, cardiac output
  - Ventilatory response to exercise – control of response, breathing frequency, tidal volume, ventilation perfusion ratio during exercise
  - Circulatory response to exercise – redistribution of blood flow to muscles
- Limitations to exercise subjects in normal subjects
- Exercise response in disease, to include:
  - Cardiac and respiratory (obstructive and restrictive disease) – patterns of response, major limiting factors and assessments of symptoms
  - Other disorders – obesity, unfitness, malingering, deconditioning
  - Contraindications to exercise testing and safety during exercise tests
  - Recognition of indications to terminate the exercise test prematurely, e.g. symptoms

Respiratory failure
• Assessment of respiratory failure and control
• Differentiation of Type 1 and Type 2 respiratory failure
• Acute and chronic respiratory failure
• Metabolic disorders
• Treatment pathways for patients in respiratory failure
• Diagnostic procedures used in the assessment of patients with respiratory failure

**Oxygen therapy and assessment**
• National guidelines for assessment of long-term oxygen therapy and ambulatory oxygen in adults
• Protocols for the performance and assessment for oxygen therapy in adults
• Methods of oxygen delivery and interfaces
• Ordering of oxygen therapy using home oxygen order form (HOOF)
• Long-term follow-up of patients using oxygen therapy
• The use of hypoxic challenge in patients wishing to fly

**Non-invasive ventilation**
• Clinical indications for NIV
  o Acute
    ▪ Protocols for initiation and withdrawal
    ▪ Monitoring
    ▪ Requirements for invasive ventilation
  o Chronic
    ▪ Assessment for domiciliary ventilation
    ▪ Nocturnal and diurnal monitoring of patients for domiciliary ventilation
    ▪ Long-term monitoring
• Modes of ventilation (positive and negative)
  o Pressure support
  o Volume support
  o Spontaneous intermittent mechanical ventilation
• Interfaces
• Operational parameters
  o Inspiratory positive airway pressure (IPAP)
  o Expiratory positive airway pressure (EPAP)
  o Respiratory rate
  o Rise time
  o Vt

**Field exercise testing**
• Indications for performing field exercise tests
  o Objective assessment of exercise capacity
  o Assessment of symptoms
  o Unexplained dyspnoea on exertion
  o Assessment of disability
  o Desaturation on exercise
  o Serial monitoring

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Assessment for ambulatory oxygen

Field exercise protocols
- Equipment
- How to decide the most appropriate protocol to use
- Advantages and disadvantages of each protocol
- Six-minute walk, incremental shuttle walk, endurance shuttle walk
- Manual calculation of results and predicted values

Measurements
- Heart rate, oxygen saturation
- Assessment of symptoms: Borg scale, Visual Analogue Scale, Rating of Perceived Exertion
- Observation of full cardiorespiratory exercise tests

Interpretation and reporting of results
- Common patterns of results in disease: cardiac vs respiratory disease
- Symptoms
- Obstructive vs restrictive lung disease

Full cardiopulmonary exercise testing
- Indications for performing full cardiopulmonary exercise tests
  - Assessment of symptoms
  - Differentiation of cardiac versus respiratory impairment
  - Unexplained dyspnoea
  - Assessment for surgery
- Exercise protocols
  - Maximal vs submaximal
  - Advantages and disadvantages
  - Cycle ergometer vs treadmill
  - How to decide on the most appropriate protocol
- Principles of equipment
  - Gas analysis
  - Volume measurement
  - Blood gases
  - Quality control and calibration
  - Graphical representation of results
- Measurements
  - Ventilation and frequency
  - Oxygen uptake and carbon dioxide output
  - Heart rate and oxygen pulse
  - Respiratory exchange ratio
  - Oxygen saturation
  - Assessment of symptoms
- Exercise facilities
  - Health and safety requirements
  - Basic Life Support/Advanced Life Support, resuscitation equipment and oxygen
- Concepts of interpretation of results
  - Graphs and flow charts
  - Common patterns of results in disease: cardiac vs respiratory
  - Symptoms
Breathing reserve
Cardiac reserve
Obstructive vs restrictive lung disease
Cardiac disease
Use of anaerobic threshold in interpretation

**Interpretation**
- Application of various respiratory tests in the confirmation of disease
- Awareness of clinical guidelines, e.g. COPD, asthma
- Clinical report writing techniques
- The role of the respiratory physiologist and critical care scientist in the multidisciplinary team

**Lifestyle changes**
- Smoking cessation strategies
- Exercise prescription
- Weight management
- Pulmonary rehabilitation

**Division:** Physical Sciences and Biomedical Engineering  
**Theme:** Cardiac, Critical Care, Vascular, Respiratory and Sleep Sciences  
**Specialism:** Critical Care Science  
**Years 2 and 3:** Research Project  
**[60 credits]**

The overall aim of this module, building on the Research Methods module, is for the trainee to undertake a research project that shows originality in the application of knowledge, together with a practical understanding of how established techniques of research and enquiry are used to create and interpret knowledge in a specialism of healthcare science. The research project may span scientific or clinical research, translational research, operational and policy research, clinical education research, innovation, service development, service improvement, or supporting professional service users to meet the expected learning outcomes. Research projects should be designed to take into account the research training required by individual trainees and the needs of the department in which the research is to be conducted.

**Learning Outcomes: Knowledge and Understanding**

On successful completion of this module the trainee will:

1. Discuss the stages of the research and innovation process from conceptualisation to dissemination and, if appropriate, translation into practice.
2. Describe the purpose and importance of different kinds of research, including scientific or clinical research, translational research, operational and policy research, clinical education research, innovation, service development, service improvement and supporting professional service...
users, and relate these to the roles undertaken by Clinical Scientists in the trainee’s specialism.
3. Discuss and evaluate the use of reference manager systems.
4. Justify the rationale for research governance and ethical frameworks when undertaking research or innovation in the NHS.
5. Describe the process and requirements for publication in a peer-reviewed journal and the current system of grading research publications.

Learning Outcomes: Practical Skills

On successful completion of this module the trainee will:

1. Design, plan and undertake a research project to test a hypothesis from conception to completion/archiving in accordance with ethical and research governance regulations, drawing on expert advice where necessary and involving patients and service users.
2. Analyse the data using appropriate methods and statistical techniques, and interpret, critically discuss and draw conclusions from the data.
3. Prepare a written project that describes and critically evaluates the research project, clearly identifying the strengths and weaknesses.
4. Present a summary of the research project and outcome that conforms to the format of a typical scientific presentation at a national or international scientific meeting, responding to questions appropriately.
5. Prepare a summary of the research project suitable for non-specialist and lay audiences.

Indicative Content
- Critical evaluation of the literature/evidence base
- Reference management
- Identification of a research question
- Research ethics and regulatory requirements, including issues related to access and use of information
- Data protection and confidentiality guidelines
- Patient safety
- Patient consent
- Sources of funding/grants
- Peer review/expert advice
- Possible risks and balancing risk vs benefit
- Project management techniques and tools
- Roles and responsibilities of those involved in the research
- Monitoring and reporting
- Data analysis
- Data interpretation
- Criteria/metric for assessing and grading research data and publications in the scientific, NHS and HE sectors
- Range of formats and modes of presentation of data
- Requirements for publications submitted to scientific, education and similar journals
- Current conventions with respect to bibliography and referencing of information
Year 3 Critical Care Science Specialist Practice

Division: Physiological Sciences
Theme: Cardiac, Critical Care, Vascular, Respiratory and Sleep Sciences
Specialism: Critical Care Science
Year 3: Critical Care Science [30 credits]

Life Support and Emergency Resuscitation [10 credits]

This module provides trainees with the knowledge that underpins the third year specialist module in Critical Care Science.

**Learning Outcomes: Knowledge and Understanding**

On successful completion of this module the trainee will:

1. Describe the clinical signs associated with critical illness, their relative importance and interpretation, and the relevance of prior health status in determining risk of critical illness and outcomes.
2. Describe the effects and acute complications of severe trauma on organs and organ systems.
3. Describe the anatomy, physiology, pathophysiology and co-morbidities underlying typical conditions affecting patients admitted to an intensive care environment, including heart disease and common congenital cardiac disorders.
4. Describe the technology, techniques, equipment, preparation and precautions required for safe management of the patient airway.
5. Describe the common modes and patterns of ventilation and indications for ventilatory support, and justify the selection relative to individual patient clinical need.
6. Explain the principles of use of a range of non-invasive ventilatory therapies, including indications, limitations and techniques, modes of ventilation and the need for humidification and use of nebulisers.
7. Describe a range of advanced therapies and relate these to the patient's clinical condition and the underpinning evidence base.
8. Explain the principles, application and maintenance of volumetric and syringe-driven infusion devices.
9. Describe the principles and application of intra-aortic balloon pump (IABP) therapy, including the physiological effects and the underpinning evidence base.
10. Explain the causes of cardiorespiratory arrest, identification of patients at risk and corrective treatment of reversible causes.
11. Describe peri-arrest arrhythmias and the principles of their management.
12. Describe the current basic life support UK Resuscitation Council Guidelines, the underpinning evidence base and justify the indications for not commencing resuscitation or ceasing an initiated attempt.

13. Recognise the relevant ethical, legal, religious and cultural aspects of end of life care and the process of withholding or withdrawing treatment.

14. Discuss the legal and ethical principles underpinning organ donation and transplantation.

15. Critically evaluate the role of the critical care scientist in the current and future care and management of the critically ill.

Learning Outcomes: Associated Work Based Learning

High-level description of the work based learning that accompanies this academic module. Further details of the work based programme can be found in the Work Based Learning Guide, including the Clinical Experiential Learning, Competences and Applied Knowledge and Understanding.

On successful completion of this module the trainee will be able to:

1. Perform the selection of the appropriate mode and pattern of ventilation with respect to the patient’s sedation level and lung pathology/pathophysiology, diagnosing common problems associated with ventilator testing and application.

2. Set up, apply and manage a range of adjunct ventilation therapies, such as high frequency oscillatory ventilation (HFOV), high frequency jet ventilation (HFJV), nitric oxide therapy (NO), anaesthetic agent delivery in critical care and Heliox applications.

3. Interpret and apply the monitoring techniques available on high specification ventilators with respect to the ventilation settings.

4. Perform and manage capillary refill time (CRT) for a range of pathologies safely in accordance with current guidelines.

5. Set up and operate an intra-aortic balloon pump (IABP) with reference to safety, risk management and therapeutic effects.

6. Set up and manage a range of syringe drivers within the critical care environment.

Indicative Content

Clinical signs associated with critical illness
- Definition of critical illness
- Cardinal features of critical illness
  - Appearance
  - Neurological
  - Respiratory
  - Cardiovascular

Effects and acute complications of severe trauma on organs and organ systems
- Respiratory: thoracic trauma; acute lung injury; tension pneumothorax
- Cardiovascular: hypovolaemic shock; cardiac tamponade
• Renal: acute renal failure; rhabdomyolysis
• Neurological: altered consciousness; traumatic brain injury; post-anoxic brain injury; coup and contra-coup
• Injuries: extradural and subdural haematomas; intracranial haemorrhage and infarction; spinal cord injury
• Gastrointestinal: abdominal trauma; abdominal tamponade; rupture of liver or spleen
• Musculoskeletal system: soft tissue injury; short-term complications of fractures; fat embolism; crush injury and compartment syndromes
• Maxillofacial injuries

**Typical conditions affecting patients admitted to an intensive care environment**
• Circulatory failure, including hypovolamic shock
• Acute kidney injury
• Acute liver failure
• Neurological impairment, including epilepsy
• Acute gastrointestinal failure
• Acute lung injury syndromes, including acute respiratory distress syndrome
• Sepsis
• Intoxication with drugs or environmental toxins
• Poison (accidental and non-accidental)
• Renal failure
• Liver failure
• Multi-organ failure
• Trauma, including burn/dermal injury, spinal, chest
• Major surgery, for example hepatobilary and pancreas, maxillofacial
• Hypothermia
• Pulmonary oedema

**Causes, recognition and management of:**
• Acute chest pain
• Tachypnoea and dyspnoea
• Upper and lower airway obstruction
• Pulmonary oedema
• Pneumothorax (simple and tension)
• Hypoxaemia
• Hypotension
• Shock states
• Anaphylactic and anaphylactoid reactions
• Hypertensive emergencies
• Acute confusional states and altered consciousness
• Acute seizures/convulsions
• Oliguria and anuria
• Acute disturbances in thermoregulation

**Advanced mechanical ventilation techniques**
• Pressure-controlled ventilation
• Volume-controlled ventilation
• Pressure-regulated volume-controlled (PRVC) and autoflow
• Optimisation of pressure end expiratory pressure (PEEP)/FiO2 (concentration of inspired oxygen)
• Pressure/flow waveform interpretation
• Flow/volume, pressure volume loops
• Weaning strategies
• High frequency jet ventilation (HFJV), high frequency oscillatory ventilation (HFOV), nitrous oxide, Heliox
• Nebulisation therapies
• extracorporeal membrane oxygenation (ECMO)
• CO₂ removal (Novalung)

**Humidifiers**
• Humidity (absolute and dewpoint)
• Under humidification
• Over humidification
• Ciliary movement and lung compliance
• Hot and cold humidification
• Importance of droplet size

**Principles, application and maintenance of volumetric and syringe-driven infusion devices**
• Choice of device
• Gravity controllers (drip rate controllers, flow status systems)
• Volumetric pumps
  o Peristaltic
  o Dedicated cassette
• Syringe pumps
• Patient-controlled analgesia pumps (PCA)
• Anaesthesia pumps
• Ambulatory pumps
• Types of incidents involving infusion pumps, including extravasation
• Piggyback infusions
• Pump management
• Selection and procurement
• Reporting adverse incidents
• Preparation for use
• Maintenance and repair
• Training of staff

**Measurement of capillary reflex time**
• Indications
• Limitations
• Guidelines

**Intra-aortic balloon pump (IABP) therapy**
• Basic principles of counter pulsation
• Physiological effects of IABP therapy
  o Myocardial oxygen supply and demand
- Coronary perfusion
- Renal function
- Haematological effects

- Indications
  - Acute myocardial infarction
  - Ventricular arrhythmias
  - Cardiogenic shock
  - Unstable angina
  - Refractory ventricular failure
  - Cardiac surgery

- Contraindications
- Technique of insertion and operation
- Anticoagulation
- Complications

Causes of cardiorespiratory arrest
- Airway obstruction
- Breathing inadequacy
- Cardiac abnormalities
  - Acute coronary syndromes
- Warning signs and symptoms
- Early recognition

Peri-arrest arrhythmias
- Bradycardia
- Broad complex tachycardia
- Atrial fibrillation
- Narrow complex tachycardia

Principles and ethical issues with respect to organ donation and transplantation

Monitoring and Supporting Critically Ill Patients
[15 credits]

This module provides trainees with the knowledge and understanding that underpins the specialist module in Critical Care Science and provides the trainees with the specialist underpinning knowledge and understanding to undertake learning in the workplace.

Learning Outcomes: Knowledge and Understanding

On successful completion of this module the student will:

Safe Practice
1. Justify the indications for monitoring, the selection of suitable methods and the hazards associated with inappropriate monitoring.
2. Describe how to interpret information from monitoring devices and identify common causes of error and the principles of monitoring trends of change.
3. Critically analyse the role of the critical care scientist in the monitoring and support of patients within a critical care environment.
4. Recognise the issues governing safe patient transport with reference to current guidelines.

**Patient and Haemodynamic Monitoring**
5. Describe the methods, indications, complications, precautions and limitations for measuring and monitoring:
   i. Temperature
   ii. Oxygenation (pulse oximetry)
   iii. Carbon dioxide (end tidal CO2 monitoring)
   iv. Fluid balance (fluid input-output monitoring)
   v. Intra-abdominal pressure
   vi. Intracranial pressure
   vii. Pulmonary arterial pressure
   viii. Cerebral Doppler velocities
   ix. Cerebral blood flow
6. Describe and evaluate the management of patient and clinical data using information systems.
8. Describe methods for assessing neurological function, e.g. Glasgow Coma Scale.
9. Explain the principles of invasive and non-invasive systems available for measuring cardiac output and derived haemodynamic variables, and the site of placement of the monitoring device.
10. Describe the use, function and characteristics of pressure amplifiers, catheters, consumables, various transducers and factors that influence the quality of pressure waveform.
11. Describe venous and arterial access techniques, indications, contraindications and complications.
12. Describe cardiac catheterisation, including normal pressure waveforms, normal ranges, limitations and risks, and recognise typical abnormal recordings.
13. Relate the principles of invasive pressure monitoring, including measurement principles and design, indications, limitations and technique to care of the critically ill patient.

**Monitoring Ventilation**
14. Explain the monitoring capabilities of modern ventilation technology and the principles of monitoring ventilation.
15. Describe the set up and monitoring required to deliver anaesthetic agents safely and effectively.
16. Describe and critically evaluate the techniques used to measure VO$_2$, VCO$_2$, respiratory quotient and resting energy expenditure (REE).
17. Explain the principles of hypo/hyperthermia heating units.
18. Describe the principles, application and interpretation of the measurement of metabolic and nutritional requirements in the critically ill.

**Learning Outcomes: Associated Work Based Learning**
High-level description of the work based learning that accompanies this academic module. Further details of the work based programme can be found in the Work Based Learning Guide including the Clinical Experiential Learning, Competences and Applied Knowledge and Understanding.

On successful completion of this module the trainee will be able to:

1. Check and prepare equipment used in high-level transfer of patients.
2. Perform non-invasive ventilation.
3. Perform ECG monitoring, recognising and responding to trends in physiological variables.
4. Perform non-invasive BP monitoring, recognising and responding to trends in physiological variables.
5. Perform oxygen saturation monitoring, recognising and responding to trends in physiological variables.
6. Perform Capnography (CO\textsubscript{2}) monitoring recognising and responding to trends in physiological variables.
7. Perform invasive pressure monitoring, recognising and responding to trends in physiological variables.
8. Obtains and interprets the results from blood gas samples.
9. Perform a range of near patient tests at the point of care specific to critical care patient requirements, quality assuring the results.
10. Write a technical specification for a specialist critical care item of equipment and evaluate (both clinical and financial), procure and set up maintenance contract arrangements.
11. Write a standard operating procedure and undertake a risk analysis ensuring all relevant patient safety aspects are included.

Indicative Content

Safe monitoring practice, indications for and the selection of suitable methods of monitoring

- Advantages
- Disadvantages
- Accuracy
- Convenience
- Reliability
- Safety
- Cost
- Relevance to the patient’s condition

Anatomy and physiology

- Cardiovascular anatomy and physiology
- Coronary artery influences on cardiac rhythm.
- Myocardial / cell electrophysiology and apply knowledge to cardiac rhythms and arrhythmias.
- Principles of metabolism
  - nutrients: carbohydrates, fats, proteins, vitamins and minerals
  - metabolic pathways
  - lactate metabolism
energy production and enzymes
metabolic rate
hormonal control of metabolism: regulation of plasma glucose

Underpinning measurement principles, limitations and artefacts with respect to:
• Pressure
• Flow
• Temperature
• pH
• Oxygen
• Carbon dioxide

Pressure measurement including catheterisation
• Components and functions of an electromanometer system
  o Catheter
  o Tubing
  o Transducer
  o Amplifier and display unit
  o Zero and calibration techniques
  o Dynamics of the system
    ▪ Natural frequency
    ▪ Damping

Cardiac catheterisation
• MRSA screening and pre-assessment for cardiac catheterisation procedures
• Pathophysiology related to cardiac catheterisation
• Influence of coronary artery anatomy and patency on cardiac rhythm
• Indications, contraindications, limitations and risk factors associated with the procedure
• Importance of ECG, blood pressure and O2 saturation monitoring during the procedure
• ECG abnormalities and required interventions
• Normal pressure waveforms and normal value ranges
• Abnormal recordings and associated pathology
• Haemodynamic measurements made during cardiac catheterisation
• The influence of equipment and consumable characteristics on the quality of pressure recordings
• Techniques for venous and arterial access, indications, risks and complications
• Characteristics and use of catheters and connecting tubing
• Recognition of normal and abnormal oxygen saturation measurements and their relationship to common abnormalities
• Immediate/advanced life support in line with Resuscitation Council UK
• Production and structure of findings and storage of results

Hypo/hyperthermia heating units
• Devices used for patient and fluid warming
• Decontamination
• Operation

**Ventilation**
• Monitoring capabilities of modern ventilation technology
• Principles of monitoring ventilation
• Significance of:
  o respiratory rate
  o tidal volume
  o minute volume
  o mean, peak, end expiratory and plateau pressure
  o intrinsic and extrinsic PEEP
  o inspired oxygen concentration
  o arterial blood gas
  o acid-base status
• Basic features and principles of operation of a range of makes, models and software revisions of ventilators
• Decontamination, set-up and self-testing of ventilators
• Troubleshooting and reporting of faults
• Document control and traceability
• Modes of ventilation for non-invasive therapies
• Gas/agent monitoring
• Scavenging
• Anaesthetic agents
• Techniques used to measure:
  o VO₂
  o VCO₂
  o respiratory quotient and resting energy expenditure (REE)
• Advantages/disadvantages of measuring REE as opposed to using calculations
• Relationship between mode of ventilation and choice of parameters monitored; airflow and airway pressure waveforms

**Monitors**
• Service modes and touch calibration
• Menu navigation
• Operation and atypical faults
• Fault reporting procedures

**Temperature**
• Normal values
• Variance from normal – clinical and non-clinical reasons
• Safety

**Capnography**
• Mainstream
• Sidestream/microstream
• Equipment
• Clinical uses
Metabolic measurement
• Resting energy expenditure

Monitoring of EEG and derivatives
• Cerebral function analysis monitor (CFAM)
• Bispectral index (BIS)
• Compressed spectral array (CSA)
• Evoked potentials

Diagnostic and Therapeutic Techniques in Critical Care
[5 credits]

This module provides trainees with the knowledge that underpins the third year specialist module in Critical Care Science and gives trainees the tools to undertake learning in the workplace.

Learning Outcomes: Knowledge and Understanding
On successful completion of this module the student will:

Diagnostics
1. Justify the indications and contraindications that influence the selection of suitable methods of investigation, including the sensitivity and specificity of the investigation as related to a range of diseases commonly leading to admission to critical care.
2. Explain the basis of effective clinical decision making, including history taking and clinical examination, accurate differential diagnosis supported by critical thinking and reflection.
3. Discuss and justify the indications, limitations and basic interpretation of laboratory investigations of blood and other body fluids.

Haematology
4. Describe the principles of blood and blood component therapy.
5. Discuss the management of severe acute haemorrhage and blood transfusion, measurement of clotting times and factors and correction of coagulation disorders.

Ultrasound
6. Describe the physical principles of medical ultrasound, the indications, limitations and basic interpretation of cardiac ultrasound and wider use of ultrasound in critical care, including ultrasound techniques for vascular localisation.

Electroencephalography
7. Explain the principles and application of electroencephalogram (EEG) recordings, including the origin of the electroencephalogram related to brain structure and functions.
8. Recognise the characteristics of the normal waveforms, phenomena and normal variants in the awake and sleep EEG.
Radiology and Nuclear Medicine
9. Describe the principles, indications, contraindications and limitations of basic radiological methods, angiography, CT and MRI scanning, cardiac nuclide imaging.

Therapeutics
10. Explain how emergency external cardiac pacing is used in the critical care environment.
11. Explain the principles and the application of extracorporeal therapies related to mechanical ventilation (ECMO, CO2 removal), recognising the risks associated with anticoagulation used with extracorporeal therapies.
12. Describe the principles and application of renal replacement therapy and the underpinning evidence base.
14. Explain the principles of pharmacology, pharmacokinetics and therapeutics, and describe the mode of action of a range of drugs used in the critical care setting.
15. Critically analyse and validate all these critical care technologies, their interaction and effects on each other and the physiology and clinical condition of the patient.

Learning Outcomes: Associated Work Based Learning
High-level description of the work based learning that accompanies this academic module. Further details of the work based programme can be found in the Work Based Learning Guide, including the Clinical Experiential Learning, Competences and Applied Knowledge and Understanding.

Learning Outcomes
On successful completion of this module the trainee will:

1. Perform electrocardiography in a range of patients and interpret the results.
2. Assist in performing emergency external cardiac pacing in the critical care environment.
3. Set up and manage extracorporeal therapies related to mechanical ventilation (CO2 removal).
4. Identify the normal features of a chest X-ray and some common abnormalities seen in critically ill patients.

Indicative Content

Indications and diagnostic investigation selection
- Accuracy
- Convenience
- Reliability
• Safety
• Cost
• Relevance to the patient's condition

**Laboratory investigations of blood and other body fluids**
• Urine, cerebrospinal fluid, pleural and ascitic fluids
  o Haematology
  o Immunology
  o Cytology
  o Blood grouping and cross-matching
  o Urea, creatinine, glucose, electrolytes and lactate
  o Liver function tests
  o Drug levels in blood or plasma
  o Tests of endocrine function (diabetes, thyroid disorders, adrenal failure)
  o Microbiological surveillance and clinical sampling

**Ultrasound physics**
• Basic principles and physics of ultrasound, spectral Doppler and colour flow Doppler
• Instrumentation associated with 2D, 3D, spectral Doppler, colour flow Doppler
• Near and far fields; amplitude, intensity; power and frequency.
• Velocity, elasticity and density; acoustic impedance.
• Attenuation in tissue with reference to reflection, refraction, scattering and absorption.
• Dynamic range concept
• Specular reflection, curved and irregular surfaces
• Focusing using lenses
• Speed of sound in soft tissue; 1540 ms\(^{-1}\) and its significance
• Range determination
• Recording methods: choices, advantages and disadvantages

**Storage and display of images**
• Basic concept of digital acquisition and system systems
• Scan converters and digital memories
• Display devices and controls and recording techniques

**Transducers**
• Piezo-electric effect
• Concepts of 2D and 3D transducer construction
• Characteristics of the ultrasound beam
• Beam steering methods
• Focusing methods and the use of dual focus
• The role of intracardiac echocardiography

**Image optimisation**
• Use of gel to include infection risk from transducer and operator
• Positioning of the patient
• Standard views
Use of non-standard views
Adapting procedure where necessary

Use of ultrasound in critical care
- Ultrasound techniques for vascular localisation, including the underlying anatomy
- Principles, routes and techniques of peripheral and central venous cannulation
- At-risk patient groups potentially needing chest drain placement under ultrasound or CT guidance
- Cardiac ultrasound
  - Ventricular function
  - Filling status
  - Valve abnormalities
  - Heart size
  - Pericardial effusion with or without evidence of tamponade

Therapeutics
- Clinical conditions and ECG indicators where temporary and permanent pacing may be indicated

Pharmacology and prescribing
- Basic principles of pharmacology, pharmacokinetics and therapeutics
- Major classes of cardiac drugs, mechanisms of action, uses and significant side effects in critically ill patients
  - Anti-arrhythmic
    - Class I – sodium channel blockers (a, b, c)
    - Class II – beta blockers
    - Class III – potassium channel blockers
    - Class IV – calcium channel blockers
  - Cardio-inhibitory
  - Cardiostimulatory
  - Diuretics
- Use and function of:
  - Thrombolytics
  - Vasodilators
  - Vasoconstrictors
- Drugs used to manage hypertension and hypotension
- The clotting cascade
- Coagulopathies
  - Measuring clotting times/factors
  - Prothrombin time (PT)
  - Activated partial thromboplastin time (APTT)
  - Fibrinogen (FIB)
  - Activated clotting time (ACT)
- Thromboelastogram

Principles and application of renal replacement therapy
- Renal pathology, pathophysiology
- Continuous veno-venous haemofiltration (CVVH)
• Continuous arteriovenous haemofiltration (CAVH)
• Continuous veno-venous haemodialysis (CVVHD)
• Continuous veno-venous haemodiafiltration (CVVHDF)
• Intermittent peritoneal dialysis (IPD)
• Fluid balance and treatment prescription in relation to the clinical condition of the patient
• Fluid and electrolyte management
**Section 14: MSc Clinical Science Specialist Modules for Respiratory and Sleep Science**

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<td>Year 1</td>
<td>Introduction to Healthcare Science, Professional Practice and Clinical Leadership</td>
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- **Generic Modules**: Common to all divisions of healthcare science
- **Division/Theme-Specific Modules**: Common to a division or theme
- **Specialist Modules**: Specific to a specialism
This module provides trainees with the knowledge that underpins the specialist module in Respiratory and Sleep Science and gives trainees the tools to undertake project-based learning in the workplace.

**Division:** Physiological Sciences  
**Theme:** Cardiac, Critical Care, Vascular, Respiratory and Sleep Sciences  
**Specialism:** Respiratory and Sleep Sciences  
**Year 2:**  
Respiratory and Sleep Science 1 (R&SS-5)  
[20 credits]

### Learning Outcomes: Knowledge and Understanding

On successful completion of this module the trainee will:

1. Describe the change in lung function from birth to adulthood and old age and the adaptation of respiratory investigations in the young cohort.
2. Recall the anatomy, physiology and common pathophysiological changes of the respiratory system.
3. Describe the features of a normal chest X-ray and identify common abnormalities.
4. Discuss the public health issues that impact on patient's commonly referred to a respiratory and sleep diagnostic service.
5. Recognise the role of health promotion, behavioural change models and the role of the healthcare scientist in supporting behavioural change.

#### Respiratory Science

7. Describe the full range of challenge tests described in the literature and the theory and application of intrinsic and extrinsic challenge testing, including the assessment of occupational disorders.
8. Explain and evaluate the methods for measuring airway function and mechanics and describe the role of respiratory mechanics (muscle and chest wall) and its assessment in clinical practice.
9. Explain and evaluate the role of respiratory muscle assessment in lung function testing and the patterns of results associated with respiratory muscle disorders.
10. Critically evaluate the role of advanced respiratory investigations and therapeutics in the investigation and management of patients with respiratory diseases.

#### Sleep Science

11. Explain the physiology and structure of sleep and the clinical aspects of normal human sleep, including the normal cardiorespiratory changes during sleep.
12. Discuss the structure and physiology of the larynx, pharynx and nasal airways, and their relevance to sleep maintenance and airway patency.
during sleep.
13. Describe and evaluate the tools, techniques and equipment used to assess and treat respiratory and neurological sleep disorders.
14. Explain the use of continuous positive airway pressure (CPAP) and non-invasive ventilation in the treatment of obstructive sleep apnoea or obesity hypoventilation syndromes.
15. Describe the theory, practice, parameters, advantages and limitations of non-ventilator techniques used in treating obstructive sleep apnoea/hypopnoea syndrome (OSAHS).
16. Discuss the effects and consequences of daytime sleepiness and sleep deprivation on whole body function, mental agility and memory consolidation, including the DVLA for fitness to drive regulations.

Pharmacology and Therapeutics
17. Explain the pharmacology, mode, sites and duration of actions of major drug classes used to treat respiratory disease and disorders of sleep.
18. Describe the effects of the common pain relief medications and of recreational drugs, including alcohol, on sleep.
19. Describe the process of drug deposition within the respiratory tract and how it is influenced by disease.
20. Describe the different delivery systems for respiratory medications.

Learning Outcomes: Associated Work Based Learning

High-level description of the work based learning that accompanies this academic module. Further details of the work based programme can be found in the Work Based Learning Guide, including the Clinical Experiential Learning, Competences and Applied Knowledge and Understanding.

On successful completion of this module the trainee will:

1. Clinically interpret spirometry, bronchodilator response, lung volumes and gas transfer in a range of patients, including those with more complex conditions. Such conditions may include, but not be limited to, patients with scoliosis, sensory limitations and learning disabilities, and neuromuscular compromised patients.
2. Plan, prepare and undertake a range of respiratory investigations, including challenge testing and non-invasive respiratory muscle function measurements.
3. Plan, prepare and undertake complete overnight pulse oximetry and limited multichannel recordings in a variety of patient conditions to obtain a range of subjective measurements of sleepiness in patients presenting with excessive daytime sleepiness.
4. Plan, prepare and undertake trials of the effectiveness of CPAP therapy to assess patients’ interface requirements and commence ventilation using appropriate settings.
5. Interpret data from challenge testing, non-invasive respiratory muscle function measurement and assessment of the response to respiratory pharmacotherapy.
6. Interpret data from overnight pulse oximetry and limited multichannel sleep recordings and produce high-quality reports, including recommendations for further management.
7. Carry out routine maintenance, calibration and quality assurance procedures on the equipment used to undertake spirometry, lung volumes, gas transfer, challenge testing and assessment of non-invasive muscle function, and assess the response to respiratory pharmacotherapy, measurement of overnight pulse oximetry and CPAP equipment.

Indicative Content

Anatomy and function of respiratory and sleep systems
- Development, structure and function of the normal chest and lung
- Airways
  - Upper and lower, including larynx, pharynx and nasal airways
- Lungs
- Chest wall
  - Respiratory muscle function
  - Lung mechanics
- Gas exchange
  - Ventilation
  - Perfusion
  - Ventilation and perfusion matching
- Normal and abnormal flora of the respiratory tract
- The importance of infection as a cause of respiratory disease
- Acid-base balance
- Allergy
- Control of ventilation during wakefulness and sleep
- Nervous system
  - Central nervous system anatomy chemistry and sleep related physiology
  - Sympathetic and parasympathetic nervous system
  - Non-adrenergic non-cholinergic
  - Receptors
  - Drug/receptor interactions

Chest X-ray
- Normal X-ray
- Indications, limitations
- Common abnormalities

Drugs
- Bronchodilators; short and long acting
- Inhaled and oral corticosteroids
- Leukotriene receptor antagonists
- Immunosuppressants
- Antibiotics
- Cromoglycates
Pharmacology
- Pharmacokinetics
- Aerosol kinetics
- Toxicological responses to drugs
- Absorption, clearance and dissolution in the lung and the systemic circulation
- Roles of drug in the management of respiratory diseases and sleep disorders
- Respiratory drugs
- Other inhaled drugs
- Common non-respiratory drugs affecting the respiratory system

Delivery devices
- Metered dose inhalers
- Dry powder devices
- Volume holding devices/large volume spacers
- Nebulisers

Guidelines for assessing response to pharmacotherapy
- Protocols for the assessment of response to respiratory and sleep medication
- Advantages and disadvantages of techniques
- Interpretation of response to treatment

Public health issues in relation to respiratory disease and sleep disorders

Health promotion
- Smoking
- Alcohol
- Obesity
- Nutrition
- Social deprivation
- Occupation
- Exercise
- Mental health
- Sleep hygiene

Extrinsic challenge testing, including the assessment of occupational disorders
- Pathophysiology of hyper-responsiveness
  - Role of inflammatory cells
  - Changes in bronchial smooth muscle
  - Pathways that cause airways narrowing
  - Effect of pharmacological therapies
- Hyper-responsive disease processes
  - Causes of hyper-responsiveness
  - Changes in hyper-responsiveness
  - Hypersensitivity and hyperactivity
Effects of genetics and the environment

Indications and contraindications for challenge testing

Pharmacological challenges
  - Direct action
    - Methacholine
    - Histamine
  - Indirect action
    - Mannitol
    - Adenosine 5-monophosphate
    - Bradykinin
    - Tachykinins
    - Leukotrienes
    - Sodium metabisulphide

Physical challenges
  - Exercise
  - Cold and dry air
  - Mannitol
  - Hypertonic saline
  - Distilled water
  - Allergen

Pharmacology and/or mode of action of bronchoconstricting agents (to include all of those mentioned previously)
  - Chemical composition, particle size, pharmacokinetics
  - Receptors
    - Binding sites
  - Site of action
  - Side effects and drug interactions
  - Normal response to inhalation of agent

Delivery devices/equipment for the above methods

Calibration, verification, cleaning, maintenance, test protocols and guidelines
  - Dosimeter
  - Nebuliser
  - Yan
  - Inhaler
  - Cold air production unit
  - Bicycle/treadmill and dry air (cylinder/Douglas bag)

Measuring the response
  - End point
  - Remedial action in the event of patient distress

Hypersensitivity reactions and risk of anaphylaxis

Recovery
  - Use of bronchodilators

Advantages and disadvantages

Calculation of results (by formula and graph, where applicable)
  - $PD_{20}$, $PC_{20}$, $PD_{15}$, $PC_{15}$, $PD_{35}$, and $PC_{35}$ (related to appropriate test)
  - Dose response curves
  - % drop from baseline tests

Interpretation

Reporting the results
• Application of above techniques in the determination of occupational hyper-responsiveness

Methods for measuring airway function and mechanics
• Bedside and clinic tests
  o Patient history and examination, e.g. obvious wasting, dyspnoea, impairment of cough, paradoxical movement of chest wall, etc.
  o Imaging
  o Blood gases
  o Vital capacity
  o Flow volume curves
  o Lung volumes
  o Gas transfer
  o Overnight pulse oximetry

Role of respiratory mechanics (muscle and chest wall)
• Anatomy of the respiratory muscles, to include
  o principal inspiratory muscles and accessory muscles and outline of expiratory muscles
• Innervation and blood supply of muscles of respiration
• Lung mechanics, to include action of muscles during the breathing cycle and pressure changes during respiration
• Control of respiration, to include brain centres, reflexes and chemoreceptors
• Physiology of muscle contraction
• Load/capacity ratio of respiratory muscles
• Respiratory muscle fatigue
• Tension time index

Assessment of respiratory mechanics in clinical practice
• Mouth pressures
  o Maximal inspiratory and expiratory mouth pressures
  o Protocol for testing
  o Measurement technique and acceptability criteria
  o Normal values and reference equations
  o Advantages and disadvantages
  o Equipment
• Nasal pressures
  o Maximal inspiratory sniff pressures
  o Measurement technique and acceptability criteria
  o Normal values and reference equations
  o Advantages and disadvantages
  o Equipment
  o Sniff, Pdi (transdiaphragmatic pressure) and Poes (oesophageal pressure)
  o Method of measurement
  o Advantages and disadvantages
• Non-volitional tests
  o Phrenic nerve stimulation
- Magnetic stimulation

- Others measurements of respiratory muscle function
  - Whistle mouth pressure
  - Cough gastric pressure
  - Respiratory muscle endurance
  - Inspiratory threshold loading
  - Respiratory muscle fatigue

**Respiratory sleep diagnostics and therapy**

- Assessment of sleep disordered breathing
  - Overnight oximetry
  - Multichannel sleep studies
  - Sleep questionnaires

- Principles of operation of equipment for the assessment of sleep-disordered breathing
  - Pulse oximetry and heart rate measurement
  - Multichannel sleep equipment to include measurements of airflow, chest and abdominal wall movement, position, leg movements and sound

- Use, delivery modes and available interfaces of CPAP in the treatment of sleep disordered breathing
  - Autotitrating vs fixed pressure
  - Comfort modes
  - NIV vs CPAP
  - Compliance data

- Interpretation of diagnostics sleep studies
  - National and international guidelines
  - AHI, ODI, pulse rises
  - Appreciate the indications for further investigations
  - Therapeutic thresholds
  - Lifestyle issues

- Assessment of therapeutic intervention
  - Compliance data and analysis
  - Assessment of sleep investigations and symptoms post treatment

- DVLA guidelines
  - Implications for category 1 and 3 driving
  - The role of the clinical scientist in the patients awareness of the DVLA guidance

**Co-morbidities associated with obstructive sleep apnoea (OSA)**

- Hypertension and cardiac arrhythmias
- Type II diabetes
- Depression
- Excessive daytime somnolence (EDS)
- Hypothyroidism

**Factors leading to nocturnal hypoventilation +/- carbon dioxide retention**

- Brainstem abnormalities
- Acquired secondary loss of ventilatory drive
- Chest wall abnormalities
- Tests for NIV assessment

**Common respiratory and sleep conditions and associated pathophysiology**
- COPD
- Asthma
- Pneumonia
- Pleural disease
- Lung cancer
- Respiratory failure
- Tuberculosis
- Pulmonary embolism and DVT
- Interstitial lung disease
- Obstructive sleep apnoea
- Obesity hypoventilation syndrome
- Cystic fibrosis
- Bronchiectasis
- Respiratory failure and cor pulmonale
- Pulmonary hypertension

**Division:** Physiological Sciences  
**Theme:** Cardiac, Vascular, Respiratory and Sleep Sciences  
**Specialism:** Respiratory and Sleep Sciences  
**Year 2s and 3:**  
**Research Project Respiratory and Sleep Sciences**  
[60 credits]

The overall aim of this module, building on the Research Methods module, is for the trainee to undertake a research project that shows originality in the application of knowledge, together with a practical understanding of how established techniques of research and enquiry are used to create and interpret knowledge in a specialism of healthcare science. The research project may span scientific or clinical research, translational research, operational and policy research, clinical education research, innovation, service development, service improvement, or supporting professional service users to meet the expected learning outcomes. Research projects should be designed to take into account the research training required by individual trainees and the needs of the department in which the research is to be conducted.

**Learning Outcomes: Knowledge and Understanding**

On successful completion of this module the trainee will:

1. Discuss the stages of the research and innovation process from conceptualisation to dissemination and, if appropriate, translation into practice.
2. Describe the purpose and importance of different kinds of research, including scientific or clinical research, translational research, operational and policy research, clinical education research, innovation, service development, service improvement and supporting professional service users, and relate these to the roles undertaken by Clinical Scientists in the trainee’s specialism.

3. Discuss and evaluate the use of reference manager systems.

4. Justify the rationale for research governance and ethical frameworks when undertaking research or innovation in the NHS.

5. Describe the process and requirements for publication in a peer-reviewed journal and the current system of grading research publications.

Learning Outcomes: Practical Skills

On successful completion of this module the trainee will:

1. Design, plan and undertake a research project to test a hypothesis from conception to completion/archiving in accordance with ethical and research governance regulations, drawing on expert advice where necessary and involving patients and service users.

2. Analyse the data using appropriate methods and statistical techniques, and interpret, critically discuss and draw conclusions from the data.

3. Prepare a written project that describes and critically evaluates the research project, clearly identifying the strengths and weaknesses.

4. Present a summary of the research project and outcome that conforms to the format of a typical scientific presentation at a national or international scientific meeting, responding to questions appropriately.

5. Prepare a summary of the research project suitable for non-specialist and lay audiences.

Indicative Content

- Critical evaluation of the literature/evidence base
- Reference management
- Identification of a research question
- Research ethics and regulatory requirements, including issues related to access and use of information
- Data protection and confidentiality guidelines
- Patient safety
- Patient consent
- Sources of funding/grants
- Peer review/expert advice
- Possible risks and balancing risk vs benefit
- Project management techniques and tools
- Roles and responsibilities of those involved in the research
- Monitoring and reporting
- Data analysis
- Data interpretation
- Criteria/metric for assessing and grading research data and publications in the scientific, NHS and HE sectors
- Range of formats and modes of presentation of data
- Requirements for publications submitted to scientific, education and similar journals
- Current conventions with respect to bibliography and referencing of information

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This module provides trainees with the knowledge that underpins the third year specialist module in Respiratory and Sleep Science and gives trainees the tools to undertake learning in the workplace.

**Learning Outcomes: Knowledge and Understanding**

On successful completion of this module the trainee will:

1. Describe the structure, function, mechanics and control of the cardiorespiratory system and discuss the pathophysiology of common causes of respiratory failure.
2. Describe and critically evaluate the role of field exercise testing in the assessment for ambulatory oxygen and the role of short- and long-term oxygen therapy in the treatment of disease.
3. Describe the role of non-invasive ventilation in the treatment of acute and chronic respiratory failure in a range of disorders.
4. Discuss the range of ventilators available for non-invasive ventilation and compare and contrast their modes of action and functions.
5. Discuss the principles underpinning the assessment and monitoring of patients receiving non-invasive ventilation in the acute and chronic setting.
6. Explain the methods of measuring physiological changes during exercise and the physiological adaptations that occur with exercise training.
7. Compare and contrast the range of exercise tests available and their clinical application, including the application of cardiopulmonary exercise testing in the assessment of limitations to exercise.
8. Discuss the application of interpretation strategies to respiratory investigations.

**Sleep Science**

9. Discuss the physiology and structure of sleep throughout life and the pathophysiology of non-respiratory sleep disorders, relating changes in physiology due to neurodegenerative sleep disorders.
10. Discuss the use and principles of sleep polysomnography in the assessment of sleep and disorders of sleep and the role of video-polysomnographic recording in differential diagnosis.
11. Discuss the use and principles of neurophysiological recording equipment and identification of the characteristics of the normal waveforms/variation,
12. Describe the normal structure and function and chemistry of the neural pathways relating to sleep and wakefulness, circadian rhythm generation and its interaction with body function.
13. Discuss the use of psychological tools to treat hyper and hypo-somnolence.
14. Define the uses and limitations of tests of vigilance and sleep maintenance.

Learning Outcomes: Associated Work Based Learning

High-level description of the work based learning that accompanies this academic module. Further details of the work based programme can be found in the Work Based Learning Guide, including the Clinical Experiential Learning, Competences and Applied Knowledge and Understanding.

On successful completion of this module the trainee will:

1. Perform and interpret assessments of blood gas status and identify the requirements for supplemental oxygen therapy.
2. Perform full cardiopulmonary exercise testing in the investigation of respiratory, vascular and cardiac disease.
3. Identify the requirement for and initiate non-invasive ventilation (NIV) in patients with both acute and chronic respiratory failure.
4. Discuss and agree management strategies for disorders of respiratory or sleep and demonstrate the communication skills required to discuss subjects that may be difficult and work with patients.
5. Perform, analyse and technically report polysomnographic sleep investigations in patients referred to a sleep service.

Indicative Content

Structure, function, mechanics and control of the cardiorespiratory system
- Blood gas physiology
- Acid-base balance
- Ventilation
- Gas transport and exchange

Oxygen therapy and assessment
- Principles and role of short- and long-term oxygen therapy in the treatment of disease
- Evidence base for oxygen prescription and assessment of patients for long-term oxygen therapy
- Process for ordering oxygen therapy
- National guidelines for assessment of long-term oxygen therapy and ambulatory oxygen in adults
- Protocols for the performance and assessment for oxygen therapy in adults
- Methods of oxygen delivery and interfaces
- Ordering of oxygen therapy using home oxygen order form (HOOF)
• Long-term follow-up of patients using oxygen therapy
• The use of hypoxic challenge in patients wishing to fly

Cardiorespiratory responses to exercise
• Normal response to exercise, to include:
  o muscles – structure, metabolism, substrates
  o cardiac response to exercise – control of response, cardiac frequency and stroke volume, cardiac output
  o ventilatory response to exercise – control of response, breathing frequency, tidal volume, ventilation perfusion ratio during exercise
  o circulatory response to exercise – redistribution of blood flow to muscles
• Limitations to exercise subjects in normal subjects
• Exercise response in disease, to include:
  o cardiac and respiratory (obstructive and restrictive disease) – patterns of response, major limiting factors and assessments of symptoms
  o other disorders – obesity, unfitness, malingering, deconditioning
  o contraindications to exercise testing and safety during exercise tests
  o recognition of indications to terminate the exercise test prematurely, e.g. symptoms
• Common protocols used in cardiopulmonary exercise testing
• Uses and limitations of cardiopulmonary exercise testing and its value in clinical practice

 Respiratory failure
• Assessment of respiratory failure and control
• Differentiation of Type 1 and Type 2 respiratory failure
• Acute and chronic respiratory failure
• Metabolic disorders
• Treatment pathways for patients in respiratory failure
• Diagnostic procedures used in the assessment of patients with respiratory failure

Non-invasive ventilation
• Role of non-invasive ventilation in the treatment of acute and chronic respiratory failure in a range of disorders
  o Airway
  o Chest wall
  o Muscle disorders
• Clinical indications for NIV
  o Acute
    ▪ Protocols for initiation and withdrawal
    ▪ Monitoring
    ▪ Requirements for invasive ventilation
  o Chronic
    ▪ Assessment for domiciliary ventilation
    ▪ Nocturnal and diurnal monitoring of patients for domiciliary ventilation
    ▪ Long-term monitoring
Modes of ventilation (positive and negative)
  - Pressure support
  - Volume support
  - Spontaneous Intermittent mechanical ventilation

Interfaces

Operational parameters
  - IPAP
  - EPAP
  - Respiratory rate
  - Rise time
  - Vt

Field exercise testing

Indications for performing field exercise tests
  - Objective assessment of exercise capacity
  - Assessment of symptoms
  - Unexplained dyspnoea on exertion
  - Assessment of disability
  - Desaturation on exercise
  - Serial monitoring
  - Assessment for ambulatory oxygen

Field exercise protocols
  - Equipment
  - How to decide the most appropriate protocol to use
  - Advantages and disadvantages of each protocol
  - Six-minute walk, incremental shuttle walk, endurance shuttle walk
  - Manual calculation of results and predicted values

Measurements
  - Heart rate, oxygen saturation
  - Assessment of symptoms: Borg scale, Visual Analogue Scale, Rating of Perceived Exertion
  - Observation of full cardiorespiratory exercise tests

Interpretation and reporting of results
  - Common patterns of results in disease: cardiac vs respirator disease
  - Symptoms
  - Obstructive vs restrictive lung disease

Full cardiopulmonary exercise testing

Indications for performing full cardiopulmonary exercise tests
  - Assessment of symptoms
  - Differentiation of cardiac versus respiratory impairment
  - Unexplained dyspnoea
  - Assessment for surgery

Exercise protocols
  - Maximal vs submaximal
  - Advantages and disadvantages
  - Cycle ergometer vs treadmill
  - How to decide on the most appropriate protocol

Principals of equipment
- Gas analysis
- Volume measurement
- Blood gases
- Quality control and calibration
- Graphical representation of results

- Measurements
  - Ventilation and frequency
  - Oxygen uptake and carbon dioxide output
  - Heart rate and oxygen pulse
  - Respiratory exchange ratio
  - Oxygen saturation
  - Assessment of symptoms

- Exercise facilities
  - Health and safety requirements
  - BLS/ALS, resuscitation equipment and oxygen

- Concepts of interpretation of results
  - Graphs and flow charts
  - Common patterns of results in disease: cardiac vs respiratory
  - Symptoms
  - Breathing reserve
  - Cardiac reserve
  - Obstructive vs restrictive lung disease
  - Cardiac disease
  - Use of anaerobic threshold in interpretation

Interpretation
- Application of various respiratory tests in the confirmation of disease
- Awareness of clinical guidelines, e.g. COPD, asthma
- Clinical report writing techniques
- The role of the respiratory physiologist in the multidisciplinary team

Lifestyle changes
- Smoking cessation strategies
- Exercise prescription
- Weight management
- Pulmonary rehabilitation

Sleep physiology
- Normal sleep and sleep throughout life, including in paediatrics, children, pregnancy and the elderly
- Theories for why we sleep and experimental evidence
- Circadian rhythm sleep/wake timing and distribution and its effect on other body systems
- Stages of sleep and their characteristics
- Melanopsin
- Melatonin
- Pineal gland
- Suprachiasmatic nucleus
- Genetics of circadian rhythms
• Sleep/wake areas of the brain
• Reticular activation system
• Brainstem, anterior and posterior hypothalamus
• Neurochemicals associated with sleep/wakefulness and their mechanisms of action
• Brain electrical activity during sleep, pyramidal cells in the cortex

**Structure of sleep**
• Normal sleep architecture
• Standard hypnogram
• Staging of sleep according to Retschaffen and Kales, as well as AASM characteristics of REM and non-REM sleep
• Sleep and other organs

**Sleep disorders**
• Clinical aspects of normal human sleep
• Phenomena including vertex sharp waves, sleep spindles, K complexes and positive occipital sharp transients of sleep (POSTs)
• Sleep deprivation and drug-induced sleep
• Different sleep stage scoring, including:
  o Rechtschaffen and Kales
  o AASM
• Parasomnias, insomnias, hypersomnias
• Assessment of excessive daytime sleepiness
• Multi-sleep latency test (MSLT), wakefulness test, Stanford sleepiness scale

**Sleep deprivation**
• Theories of sleep homeostasis
• S process
• Adenosine
• Consequences of human sleep deprivation
• DVLA guidelines
• Sleep synchronisation
• Daytime sleepiness and vigilance testing
• Sleep history recording
  o Sleep diary
  o Actimeter
  o Vigilance tasks

**Sleep pathophysiology**
• Pathophysiology of non-respiratory sleep disorders, including the more common
  o Insomnias
  o Hypersomnias
  o Parasomnias
  o Sleep disorders related to other medical conditions
• The role of sleep in endocrine regulation and the interactions between them
- Discuss the relationships between sleep and the metabolic syndrome
- Epidemiology of common sleep disorders
- Effect of other medical disorders on sleep
- Non-REM disorders
  - Restless legs and periodic limb movement disorder
  - Sleep walking and night terrors
  - Nocturnal enuresis
- REM disorders
  - Nightmares
  - Narcolepsy
  - REM behaviour disorder
- Other sleep disorders
  - Sleep apnoea
  - Circadian rhythm disorders
  - Insomnia
  - Primary hypersomnolence

**Sleep polysomnography**

- Principles of polysomnography and individual components of measurement
  - Oximetry
  - Respiratory effort
  - Airflow
  - Body position
  - Sound
  - Limb movement
  - EEG
  - EOG
  - EMG
  - ECG
  - TcCO2
  - Oesophageal pressure and pH
  - Principles of each sensor, e.g. thermocouple vs thermister, piezo vs RIP
- Equipment set-up, calibration, recording and infection control
- Signal analysis, sleep staging, event and arousal quantification
- Cardiac arrhythmia identification
- Differential diagnosis of sleep disorders using polysomnography
- Sleep study reporting
- Parasomnias identification and classification
- Electrode/transducer placement
- Differential diagnosis using the
  - Electroencephalogram
  - Electrooculogram
- Submental muscle
- Respiratory effort and movement
- Oronasal airflow

**Video-polysomnography**
• Differentiation between epileptic and non-epileptic sleep events with respect of timing, waveforms and behaviour patterns from video-polysomnography

**Electroencephalography**
• Origin of the electroencephalogram related to brain structure and functions
• Different electrode derivations
• Internal and external calibration.
• Derivation
• Bipolar, common reference and average, source derivation
• Montage design

**Instrumentation**
• Amplifiers, filters, signal average, delay lines and triggers
• Internal and external calibration procedure on neurophysiological recording equipment

**Disorders of sleep**
• Differentiation between epileptic and non-epileptic attacks and classification of seizures (in known epilepsy)
• Uses of ambulatory neurological and respiratory recorders in sleep disorders
• Hypersomnias
• Parasomnias
• Sleep apnoea
• Periodic movements of sleep

**Multiple Sleep Latency Test (MSLT), Maintenance of Wakefulness Test (MWT) and vigilance tasks**
• Issue patient instructions
• Undertake calibration and signal maintenance
• Terminate naps appropriately
• Undertake scoring, interpreting and report generation
• Re-process equipment, undertake infection control

**Multiple Sleep Latency Test**
• Principles of polysomnography and individual components of measurement (review); principles of MSLT protocol and behavioural control
• Preparation of the patient
• Equipment set-up, calibration, recording and infection control
• Signal analysis, sleep staging, terminating naps, terminating study
• Differential diagnosis of sleep disorders using MSLT

**Maintenance of Wakefulness Test**
• Principles of polysomnography and individual components of measurement (review); principles of MWT protocol and behavioural control
• Preparation of the patient
• Equipment set-up, calibration, recording and infection control
• Signal analysis, sleep staging, terminating naps
• Differential diagnosis of sleep disorders using MSLT

Vigilance testing
• Clinical application of vigilance testing
• Examples of different tests, including but not restricted to:
  o Osler
  o Psychovigilance test (PVT)

Actigraphy, sleep diaries, sleep history, questionnaires
• Prepare equipment
• Issue patient instructions
• Download data, accept/reject results
• Undertake reaction time tests
• Interpret and report results including scoring, interpreting and report generation
• Recommend behaviour strategies for circadian rhythm adjustment
• Re-process equipment, undertake infection control

Non-invasive set-up
• Use of a range of NIV machines and interfaces
• Simulation of common faults and rare occurrences and outcomes of these
• Assessment and interpretation of blood gases
• Assessment of outcomes
• Long-term follow-up

Biochemical assessments
• Restless legs
  o FBC
  o Ferritin levels
  o Thyroid function
• Narcolepsy
  o HLA typing
  o Urine drug screening
  o CSF hypocretin

Sleep therapeutics
• CPAP and NIV treatment (review)
• Sleep hygiene and behavioural therapies (review)

Light therapy
• Melanopsin, melatonin, suprachiasmatic nucleus
• Timing and exposure of light and melatonin for treatment of sleep phase disorders
• Central sleep neuroanatomy, including activation and suppression pathways and structures with note of transmitter and inhibitory chemicals.
• Drugs for treatment of unwanted movements in sleep, mechanisms of action and pros and cons of use
• Drugs for the treatment of cataplexy
• Effect of pharmacotherapy and recreational drugs on EEG and sleep architecture
Section 15: MSc Clinical Science Specialist Modules for Vascular Science

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<td>Peripheral Arterial (Screening and Microvasculature Diagnostics)</td>
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**Module Titles**

- **Year 1**: Core Modules
  - Introduction to Healthcare Science, Professional Practice and Clinical Leadership [20]

- **Year 2**: Specialist Modules
  - Research Methods [10]
  - Ultrasound Science, Haemodynamics and Instrumentation [20]

- **Year 3**: Specialist Modules
  - Extracranial Arterial (Imaging) [10]
  - Peripheral Venous (Imaging) [10]
  - Peripheral Arterial (Screening and Microvasculature Diagnostics) [10]

**Module Descriptions**

- **Generic Modules**: Common to all divisions of healthcare science
- **Division/Theme-Specific Modules**: Common to a division or theme
- **Specialist Modules**: Specific to a specialism
This section provides trainees with the knowledge that underpins the specialist module in Vascular Science and provides the underpinning knowledge and tools for trainees to undertake project based learning in the workplace.

Division: Physiological Sciences  
Theme: Cardiac, Critical Care, Vascular, Respiratory and Sleep Sciences  
Specialism: Vascular Science  
Year 2: Ultrasound Science, Haemodynamics and Instrumentation (USHi-5)  
[20 credits]

This module will provide trainees with the underpinning scientific knowledge and practical skills to safely and competently use ultrasound instrumentation to assess the anatomy and haemodynamics of the peripheral vascular system.

Learning Outcomes: Knowledge and Understanding

On successful completion of this module the trainee will:

1. Describe and critically evaluate the fundamental scientific principles inherent in an ultrasound image.
2. Describe the design, operation and features of vascular ultrasound instrumentation.
3. Describe the histology of arteries and veins and describe how these features are represented on an ultrasound image.
4. Discuss the haemodynamics of blood flow through normal and diseased peripheral arteries and veins and how these characteristics are represented with Doppler ultrasound.
5. Describe and critically evaluate the artefacts inherent or produced in a vascular ultrasound image/spectra and explain how they can be recognised, utilised and minimised by the user.
6. Explain and critically evaluate the accuracy, precision and sources of errors in vascular ultrasound measurements.
7. Recognise and critically evaluate the importance of labelling images, and the different methods used for storage, retrieval and post-processing of data.
8. Explain and critically evaluate the safety of diagnostic ultrasound, describe the current national safety recommendations and guidelines.
9. Describe and critically evaluate the role of quality assurance and safety assessments in an ultrasound department.
10. Recognise the range, advantages and limitations of quality assurance measurements used to assess ultrasound machines.

Learning Outcomes: Associated Work Based Learning

High-level description of the work based learning that accompanies this academic module. Further details of the work based programme can be found in the Work Based Learning Guide, including the Clinical Experiential Learning, Competences and Applied Knowledge and Understanding.

On successful completion of this module the trainee will:
1. Acquire an optimised B-mode image and evaluate the characteristic features of a normal and diseased artery and a vein on a B-mode ultrasound image.
2. Acquire an optimised colour Doppler image and evaluate the characteristic features of a normal and diseased artery and a vein on a colour Doppler image.
3. Acquire an optimised Doppler spectrum and evaluate the characteristic features of a normal and diseased artery and a vein on a Doppler spectrum with both imaging and non-imaging instrumentation.
4. Recognise, identify the cause and minimise artefacts affecting the vascular B-mode image, colour Doppler image and Doppler spectrum.
5. Obtain, record and calculate quantitative measurements from B-mode images and spectral Doppler traces. Label, record and store ultrasound images and data.
6. Identify the safety features and displays available on ultrasound instrumentation. Critically evaluate their importance and relevance and be able to manipulate controls to minimise the bio-effects and hazards of ultrasound during the acquisition of ultrasound images and Doppler spectra.
7. Carry out quality assurance (QA) measurements and safety assessments on an ultrasound machine and critically evaluate their relevance to Vascular Science.

Indicative Content

The fundamental scientific principles of diagnostic ultrasound
- Wave motion
- Frequency, speed, wavelength, acoustic pressure, intensity, power, speed of sound, bulk modulus, density, frequencies and wavelengths used in diagnosis
- Reflection, transmission, acoustic impedance, scattering, diffuse reflection, refraction, attenuation, ultrasound beams, focusing, the ultrasound pulse, non-linear propagation

Transducers and beam-forming
- Piezoelectric effect, ceramic elements
- Transducer construction
  o Basic components
  o Resonance frequency
  o Backing material
  o Impedance matching
  o Beam former and its electronics
  o Beam directivity
  o Near field, far field
  o Focusing
  o Transmit focus, dynamic receive focus
  o Dynamic aperture
  o Side lobes, grating lobes
  o Linear array
  o Curvilinear array
  o Phased array
  o Annular arrays
  o Mechanically scanned probes
  o Endo probes
  o Damage to transducers
1.5 D and 2 D arrays
- Dynamic slice thickness focusing
- Beam aberration

**Pulse-echo instrumentation**
- The range equation
- Duty factor
- Beam former
- Pulse transmitter
- Receiver
- Signal amplitude processing
- Amplification
- Analogue-to-digital conversion
- Amplitude demodulation
- Dynamic range and compression
- B-mode
- M-mode
- Harmonic imaging
- Image storage and display
- Scan converter
- Writing, reading and image freeze
- Interpolation
- Read zoom, write zoom
- Pre-processing, post-processing
- Compound imaging
- Adaptive processing
- Control nomenclature
- Control settings
- Time Gain Compensation (TGC)
- Dynamic range

**Properties, limitations and artefacts of B-mode images**
- Imaging system performance
- Artefacts (reverberation, mirror image, beam width artefacts, side lobes, grating lobes, slice thickness artefacts, shadowing and enhancement, speed of sound artefacts)
- Axial resolution, lateral resolution, slice thickness, frame rate, speckle
- Contrast resolution

**B-mode measurements**
- Measurement systems
- Distance, area and volume computations
- Measurement errors, sources of errors
- Precision and accuracy
- Interpretation of measurements

**Principles of Doppler ultrasound**
- Nature of the Doppler shift
- The Doppler equation
- Doppler ultrasound systems
• Signal received by transducer
• Continuous wave Doppler signal processor
• Continuous wave Doppler transducers
• Directional Doppler
• Origin and processing of the Doppler signal for pulsed wave systems
• Aliasing, sample volume size, time-domain systems

Blood flow
• Histology/structure of vessel walls
• Laminar, disturbed and turbulent flow, velocity profiles
• Resistance to flow
• Physiological and pathological changes that affect the arterial flow
• Venous flow
• Composition of blood
• Echogenicity of blood

Spectral Doppler ultrasound
• Spectral display
• Doppler ultrasound systems
• Spectral analysis
• Spectral Doppler controls
• Factors that affect the Doppler spectrum
• Angle insonation, angle correction
• Optimising the display
• Spectral broadening
• Effect of pathology on the Doppler sonogram
• Artefacts
• Aliasing
• High PRF mode
• Measurements and sources of errors

Colour flow imaging
• Colour flow system components
• Acquiring and processing echo signals
• Phase shift autocorrelation
• Colour flow modes
• Colour controls
  o Power
  o Gain
  o Scale
  o Focusing
  o Transmitted frequency
  o Colour assignment
  o Filter
  o Line density
  o Ensemble length and interaction with frame rate
  o Colour/B-mode priority
  o Beam steering
• Features of colour flow
• Properties of colour displays
• Artefacts
• Colour aliasing
• Time domain colour flow systems
• Measurements, Doppler power mode

Display output and storage
• Displays for ultrasonic equipment
• Printer technologies
• Digital-imaging networks
• PACs
• Responsibility for images

Quality assurance
• Clinical and technical assessment
• Applications of quality assurance
• Setting up a quality assurance program
• Standards and guidelines
• Test objects and tissue-mimicking phantoms for B-mode imaging
• Performance testing of B-mode systems
• Testing of spectral Doppler and colour flow systems

Procurement of ultrasound equipment
• Specification
• Evaluation

Safety of diagnostic ultrasound
• Risk and hazard
• Ultrasound exposure, power, intensity, pressure, acoustic output of diagnostic machines, tissue effects
• Mechanisms for the production of biological effects (ultrasound induced heating, mechanical bio-effects)
• Managing safety
• Thermal Index
• Mechanical Index
• Safety for specific use of diagnostic ultrasound epidemiology studies, in vitro cell studies
• Current safety standards and regulations
• Users’ responsibilities

Technology
• Contrast agents
• 3D
• Tissue motion
• High-frequency imaging
• Intravascular ultrasound imaging
• Elastography
• Techniques with clinical potential
• Clinical assessment of new technology

Cardiovascular haemodynamics
• Fluid properties (density, viscosity)
• Volume flow (volume flow equation)
• Energy density (potential energy, kinetic energy)
• Blood pressure
• Bernouilli principle
• Poiseuille’s equation
• Peripheral vascular resistance
• Streamlines
• Velocity profile (parabolic flow, plug flow)
• Pulsatile flow
• Flow waveforms
• Pulse wave velocity
• Wave reflections
• Relationship between flow waveform and flow profile.
• Turbulence and Reynolds number
• Turbulence due to geometry
• Flow through a stenosis (energy changes across a stenosis), entrance effects (viscous diffusion, inlet length)
• Fluid jets
• Flow in curved tubes (centrifugal force)
• Bifurcations and confluences
• Vessel diameters (circumferential stress)
• Venous pressures
• Vessel collapse
• Mechanics of valves
• Moens-Korteweg equation

**Division:** Physiological Sciences  
**Theme:** Cardiac, Vascular, Respiratory and Sleep Sciences  
**Specialism:** Vascular Science  
**Years 2 and 3:**  
**Research Project Vascular Science**  
[60 credits]

The overall aim of this module, building on the Research Methods module, is for the trainee to undertake a research project that shows originality in the application of knowledge, together with a practical understanding of how established techniques of research and enquiry are used to create and interpret knowledge in a specialism of healthcare science. The research project may span scientific or clinical research, translational research, operational and policy research, clinical education research, innovation, service development, service improvement, or supporting professional service users to meet the expected learning outcomes. Research projects should be designed to take into account the research training required by individual trainees and the needs of the department in which the research is to be conducted.

**Learning Outcomes: Knowledge and Understanding**

On successful completion of this module the trainee will:

1. Discuss the stages of the research and innovation process from
conceptualisation to dissemination and, if appropriate, translation into practice.

2. Describe the purpose and importance of different kinds of research, including scientific or clinical research, translational research, operational and policy research, clinical education research, innovation, service development, service improvement and supporting professional service users, and relate these to the roles undertaken by Clinical Scientists in the trainee’s specialism.

3. Discuss and evaluate the use of reference manager systems.

4. Justify the rationale for research governance and ethical frameworks when undertaking research or innovation in the NHS.

5. Describe the process and requirements for publication in a peer-reviewed journal and the current system of grading research publications.

Learning Outcomes: Practical Skills

On successful completion of this module the trainee will:

1. Design, plan and undertake a research project to test a hypothesis from conception to completion/archiving in accordance with ethical and research governance regulations, drawing on expert advice where necessary and involving patients and service users.

2. Analyse the data using appropriate methods and statistical techniques, and interpret, critically discuss and draw conclusions from the data.

3. Prepare a written project that describes and critically evaluates the research project, clearly identifying the strengths and weaknesses.

4. Present a summary of the research project and outcome that conforms to the format of a typical scientific presentation at a national or international scientific meeting, responding to questions appropriately.

5. Prepare a summary of the research project suitable for non-specialist and lay audiences.

Indicative Content

- Critical evaluation of the literature/evidence base
- Reference management
- Identification of a research question
- Research ethics and regulatory requirements, including issues related to access and use of information
- Data protection and confidentiality guidelines
- Patient safety
- Patient consent
- Sources of funding/grants
- Peer review/expert advice
- Possible risks and balancing risk vs benefit
- Project management techniques and tools
- Roles and responsibilities of those involved in the research
- Monitoring and reporting
- Data analysis
- Data interpretation
- Criteria/metric for assessing and grading research data and publications in the scientific, NHS and HE sectors
- Range of formats and modes of presentation of data
This module provides trainees with the knowledge that underpins the third year specialist module in Vascular Science. It will provide trainees with the knowledge, understanding and practical skills to safely contribute to the diagnosis of extracranial vascular disease and provides the knowledge that will underpin learning in the work base.

### Learning Outcomes: Knowledge and Understanding

On successful completion of this module the trainee will:

1. Recognise and identify normal and atypical extracranial vascular anatomy and pathology.
2. Explain the normal haemodynamics and physiology of the extracranial vasculature and evaluate the numerous effects of pathology on blood flow.
3. Describe the clinical use of ultrasound in the diagnosis of extracranial disease, the linkages with other imaging techniques and the clinical importance in selecting the appropriate technique for the best management of the patient.
4. Recognise the diversity and urgency of presenting signs and symptoms, and critically evaluate expected underlying haemodynamics and pathology.
5. Recognise the expected co-morbidity associated with extracranial vascular disease and the health and safety risks during the investigation.
6. Explain the infection risks associated with vascular ultrasound and cerebrovascular patients and how they are managed.
7. Describe the principles and consequences of the National Stroke Strategy and the impact this has on diagnostic vascular services and patient management.
8. Interpret extracranial ultrasound images, associated spectral data and measurements. Critically evaluate the need to select appropriate grading criteria and plaque characterisation tools for the appropriate interpretation of the data.
9. Explain and critically evaluate the need to convey complex scientific information to inform multidisciplinary teams of the diagnostic results, conclusions and consequences, in clear reports or presentations, in a clinically appropriate time frame.

### Learning Outcomes: Associated Work Based Learning

High-level description of the work based learning that accompanies this academic module. Further details of the work based programme can be found in the Work Based Learning Guide, including the Clinical Experiential Learning, Competences and Applied Knowledge and Understanding.
On successful completion of this module the trainee will:

1. Triage requests for investigation of patient with suspected carotid and vertebral artery disease and prepare the room and equipment.
2. Prepare patients and take their clinical histories.
3. Perform scans on patients with suspected carotid and vertebral artery disease.
4. Interpret, explain and report results.

Indicative Content

Overview of cerebrovascular disease
- Anatomy of extracranial and intracranial circulation
  - Brachiocephalic artery
  - Subclavian artery
  - Common carotid artery
  - External carotid artery (and cervical branches)
  - Internal carotid artery
  - Ophthalmic artery
  - Middle cerebral artery
  - Posterior cerebral artery
  - Anterior cerebral artery
  - Circle of Willis
  - Vertebral artery
  - Basilar artery
  - Morphologic variations of the cerebrovascular circulation
  - Collateral pathways
- Pathology
  - Carotid atheroma and plaque
  - Aneurysms
  - Dissection
  - Carotid body tumours
  - Arteritis
  - AV malformations
  - Acute thrombosis
- Haemodynamics of the extracranial arteries
  - Carotid arteries
    - Flow in a bifurcation
    - Boundary layer separation
    - Effect of pathology on flow
      - Relationship between velocity, flow and lumen size
      - Proximal ICA stenosis
      - Distal ICA occlusion/stenosis
      - Stump syndrome
      - Common carotid occlusion
      - Brachiophephalic disease
  - Vertebral arteries
    - Patency
    - Flow direction/steel syndrome
      - Latent, transient, permanent steel
• Presenting signs and symptoms
  o Stroke/transient ischaemic attack
    ▪ Hemiplegia, hemiparesis, hemisensory deficit
    ▪ Visual disturbances
      • Transient monocular blindness
      • Retinal emboli
      • Homonymous hemianopia
  o Speech problems
    ▪ Dysphasia – expressive/receptive
    ▪ Aphasia
    ▪ Dysarthria
  o Horner's syndrome
  o Non-focal symptoms (syncope, vertigo, ataxia, amnesia, confusion)
  o Carotid bruit (asymptomatic/symptomatic)
• Associated co-morbidity and risk factors
• Investigative techniques
  o Ultrasound
  o MRA
  o Angiography
  o CT angiography (CTA)
• Interpretation and measurement of stenosis (ECST, NASCET)
• Treatment
  o Medical management
  o Carotid endarterectomy
  o Carotid stenting
• The National Stroke Strategy

Ultrasound investigation of the extracranial arteries
• Historical perspectives and criteria developments
• Extracranial examination technique
  o Risk assessment and infection control
  o Patient preparation
  o Explanation of test
  o History taking
  o Patient positioning
• Scanning procedure and protocol
• Interpretation and determination of disease severity
  o B-mode imaging interpretation
    ▪ Estimation of stenosis based on B-mode imaging
  o Colour Doppler imaging interpretation
    ▪ Estimation of disease based on Colour duplex imaging
  o Determination of disease severity using Doppler spectral analysis
    ▪ Peak systolic velocity, end systolic velocity and %stenosis
  o The role of power Doppler
  o External carotid artery disease
  o Consensus on diagnostic criteria for grading carotid artery disease
  o Ultrasonic characterisation of carotid plaques
    ▪ Plaque classification
      • Anechoic
- Echolucent
- Echogenic
- Hyperechoic
  - Plaque composition
    - Homogeneous
    - Heterogeneous
  - Plaque surface contour
    - Smooth
    - Irregular
    - Ulceration
  - Gary-Weale/Lusby plaque classification
  - Correlation with histology
  - Natural history studies
  - Prospective studies
- Accuracy of duplex scanning in the detection of carotid disease
- Limitations, equivocal data, artefacts, conflicts and pitfalls
  - Poor cardiac output
  - Compensatory flow
  - High bifurcation
  - Proximal or distal disease
  - Occlusion vs sub-occlusion

Division: Physiological Sciences
Theme: Cardiac, Critical Care, Vascular, Respiratory and Sleep Sciences
Specialism: Vascular Science
Year 3:
Peripheral Venous (Imaging) (PVI-7)
[10 credits]

This module provides trainees with the knowledge that underpins this third year specialist module in Vascular Science. It will provide trainees with the knowledge, understanding and practical skills to safely contribute to the diagnosis of acute lower limb deep venous thrombosis and superficial thrombophlebitis.

Learning Outcomes: Knowledge and Understanding

On successful completion of this module the trainee will:

1. Recognise and identify normal and atypical peripheral venous anatomy and pathology.
2. Explain the normal haemodynamics and physiology of the peripheral venous system and evaluate the numerous effects of pathology on blood flow.
3. Discuss and justify the clinical use of ultrasound in the diagnosis of acute peripheral venous disease, the linkages with other imaging techniques and the clinical importance in selecting the appropriate technique for the best management of the patient.
4. Discuss and justify the diversity and urgency of presenting signs and symptoms, and critically evaluate expected underlying haemodynamics and pathology.
5. Describe the expected co-morbidity associated with venous disease and evaluate
the health and safety risks during the investigation and how they are managed.
6. Explain the infection risks associated with venous ultrasound and patients with suspected deep venous thrombosis.
7. Describe the principles of the deep venous thrombosis pathway and appraise the impact and consequences this has on diagnostic vascular services.
8. Interpret acute peripheral venous ultrasound images, associated spectral data and measurements. Critically evaluate the need to evaluate the age of thrombus and proximal extent.
9. Critically evaluate the need to convey complex scientific information to inform multidisciplinary teams of the diagnostic results, conclusions and consequences, in clear reports, in a clinically appropriate time frame.

Learning Outcomes: Associated Work Based Learning

High-level description of the work based learning that accompanies this academic module. Further details of the work based programme can be found in the Work Based Learning Guide, including the Clinical Experiential Learning, Competences and Applied Knowledge and Understanding.

On successful completion of this module the trainee will:
1. Triage request for investigation of a patient with suspected DVT and prepare the room and equipment.
2. Prepare the patient and take a clinical history.
3. Perform scans on patients with suspected DVT.
4. Interpret, explain and report results.

Indicative Content

Overview of peripheral venous disease
- Anatomy of deep lower limb veins
  - Anterior tibial veins
  - Posterior tibial veins
  - Peroneal veins
  - Gastrocnemius veins
  - Soleal sinuses
  - Popliteal vein
  - Femoral vein
  - Common femoral vein
  - Profunda vein
  - External iliac vein
  - Internal iliac vein
  - Common iliac vein
  - Inferior vena cava
- Anatomy of the superficial lower limb veins
  - Sapheno-femoral junction
  - Long saphenous vein (and branches)
  - Sapheno-popliteal junction
  - Short saphenous vein
  - Giacomini vein
• Anatomy of the perforating and communicating veins
  o Cockett’s perforators
  o Boyd’s perforators
  o Dodd’s perforator
  o Gastrocnemius perforator
• Presence and position of valves and valvular sinuses
• Morphologic variations of the vein anatomy
• Pathology
  o Acute deep vein thrombosis
  o Superficial thrombophlebitis
  o Chronic venous incompetence
  o Varicose veins, reticular veins
  o AV malformations
• Haemodynamics and normal physiology
  o Function of valves
  o Function of the calf pump
  o Effects of respiration on venous flow
  o Effect of pathology on flow
• Presenting signs and symptoms of peripheral venous disease
  o Acute DVT
  o Superficial thrombophlebitis
  o Varicose veins
  o Chronic venous insufficiency
• Associated co-morbidity and risk factors
• Imaging techniques
  o Ultrasound, venography, MRV
  o Correlation with histology
  o Natural history studies
  o Prospective studies
• Treatment
  o Medical management
  o Surgical management
• NICE guidelines

**Ultrasound investigation of acute lower limb deep venous thrombosis and superficial thrombophlebitis**

• Historical perspectives and criteria developments
• Peripheral venous examination technique
  o Risk assessment and infection control
  o Patient preparation
  o Explanation of test
  o History taking
  o Patient positioning
  o Scanning procedure and protocol
    ▪ Infra-inguinal veins
    ▪ Supra-inguinal veins
• Interpretation and determination of disease severity
  o B-mode imaging interpretation of thrombosis
    ▪ Luminal diameter and echogenicity
- Compressibility
  - Doppler imaging and spectral interpretation
    - Spontaneity of flow
    - Phasicity of flow
    - Augmentation
    - Pulsatility
- Accuracy of duplex scanning in the detection of acute venous disease
- Limitations, equivocal data, artefacts, conflicts and pitfalls
  - Suboptimal visualisation
  - Diagnosis within the pelvis
  - Bifid femoral venous systems
  - Excessive transducer pressure
  - Acute-on-chronic deep vein thrombosis
- Other findings
  - Baker’s cyst
  - False aneurysm
  - Muscle tears
  - Haematoma
  - Abscess
  - Arteriovenous fistula
  - Popliteal aneurysm

Division: Physiological Sciences
Theme: Cardiac, Critical Care, Vascular, Respiratory and Sleep Sciences
Specialism: Vascular Science
Year 3:
Peripheral Arterial Disease (Screening and Microvasculature Diagnostics) (PASMD-8)
[10 credits]

This module provides trainees with the knowledge that underpins this third year specialist module in Vascular Science. It will provide trainees with the knowledge, understanding and practical skills to safely contribute to the diagnosis and screening of peripheral arterial disease (macro and microvascular), abdominal aortic aneurysms and intracranial lesions (for sickle cell).

**Learning Outcomes: Knowledge and Understanding**

On successful completion of this module the trainee will be able to:

1. Recognise and identify normal intracranial and peripheral arterial anatomy and pathology at macro- and microvascular level.
2. Explain the normal haemodynamics and physiology of the intracranial and peripheral arterial system and evaluate the numerous effects of pathology on blood flow at a macro- and microvascular level.
3. Recognise the clinical use of microvascular instrumentation in the diagnosis of microvascular diseases, the linkages with other imaging techniques and the clinical importance of selecting the appropriate technique for the best management of the patient.
4. Describe and evaluate the clinical use of continuous wave Doppler ultrasound, segmental pressure measurements, photoplethysmography and exercise testing in the diagnosis and screening of peripheral arterial disease, the linkages with other imaging techniques and the clinical importance in selecting the appropriate technique for the best management of the patient.

5. Describe and evaluate the clinical use of ultrasound imaging in the diagnosis and screening of abdominal aortic aneurysm (AAA), the linkages with other imaging techniques and the clinical importance in selecting the appropriate technique for the best management of the patient.

6. Describe and evaluate the clinical use of transcranial pulsed Doppler ultrasound in the diagnosis and screening of intracranial lesions in sickle cell, the linkages with other imaging techniques and the clinical importance in selecting the appropriate technique for the best management of the patient.

7. Explain and recognise the diversity and urgency of presenting signs and symptoms, and critically evaluate expected underlying haemodynamics and pathology.

8. Describe the expected co-morbidity associated with arterial disease and evaluate the health and safety risks during the investigation and how they are managed.

9. Explain the infection risks associated with arterial ultrasound and patients with suspected arterial disease and how these are managed.

10. Explain the principles and consequences of national screening guidelines for AAA and sickle cell disease and the impact this has on diagnostic vascular services and patient management.

11. Explain and critically evaluate the need to convey complex scientific information to inform multidisciplinary teams of the diagnostic results, conclusions and consequences, in clear reports, in a clinically appropriate timeframe.

**Learning Outcomes: Associated Work Based Learning**

High-level description of the work based learning that accompanies this academic module. Further details of the work based programme can be found in the Work Based Learning Guide, including the Clinical Experiential Learning, Competences and Applied Knowledge and Understanding.

On successful completion of this module the trainee will:

1. Perform ultrasound scans on patients with suspected abdominal aortic aneurysm (AAA).
2. Perform resting and post-exercise Doppler assessment of patients with suspected peripheral arterial disease.
3. Obtain transcranial Doppler (TCD) spectra of the intracranial cerebrovascular circulation.
4. Obtain measurements of the microvascular system.

**Indicative Content**

**NHS AAA Screening Programme**
- Organisation of a screening service
- Ultrasound effectiveness, sensitivity and risk
- Clinical assessment

Page 146
MSc CCVRS Final Version 3.2 for 2013-14
- AAA incidence and mortality statistics
- Training and accreditation
- Quality assurance and quality control

NHS Sickle Cell Screening Programme
- Organisation of a screening service
- Ultrasound effectiveness, sensitivity and risk
- Clinical assessment
- Stroke incidence and mortality statistics
- Training and accreditation
- Quality assurance and quality control

Scientific principles of pulsed wave Doppler

Scientific principles of plethysmography
- Photoplethysmography
- Impedance plethysmography
- Displacement (pneumatic cuff)
- Strain gauge
- Oculoplethysmography pressure

Scientific principles of techniques used to investigate the microcirculation
- TCPO2
- Laser Doppler
- Thermography
- Capillaroscopy

Anatomy and physiology of the lower limb arterial circulation

Pressures (patient positioning, technique, interpretation, capabilities, limitations)
- Lower extremity
- Segmental
- Resting ankle
- Stress test
- Toe pressures

Transcranial Doppler (patient positioning, technique, interpretation, capabilities, limitations, indications)
- Intraoperative monitoring
- Closure of patent foramen ovale (PFO)

Plethysmography (venous occlusion technique, volume pulse measurements – techniques, interpretation, capabilities, limitations)
- Upper extremity
- Lower extremity
- Digits

Assessment of microvasculature
• TCP02
• Laser Doppler
• Thermography
• Capillaroscopy

Other non-invasive tests (patient positioning, technique, interpretation, capabilities, limitations)
• Hand-held Doppler examination
  o Upper limb
  o Lower limb
Appendix 1: Contributor List

Members of the STP MSc and Work Based Programme Physiological Sciences: Cardiac, Vascular, Respiratory and Sleep Sciences

Development of the STP curriculum for the MSc Clinical Sciences and Work Based programme for Medical Physics has been coordinated by the Modernising Scientific Careers team and the National School of Healthcare Science working with NHS and Higher Education colleagues. The professionals who have contributed to the development of STP Programme since 2009 include:

<table>
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<tr>
<th>Cardiac Science</th>
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<tbody>
<tr>
<td>Jane Allen</td>
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<td>Martyn Bucknall</td>
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<th>Vascular Science</th>
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<td>Abigail Thrush</td>
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<td>Barts and The London NHS Trust</td>
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Professional bodies and societies were invited to review this STP programme and their feedback has shaped the final publication:

Association for Respiratory Technology and Physiology  
British Society of Echocardiography  
British Sleep Society  
Society for Cardiological Science and Technology  
Society for Critical Care Technologies  
The Society for Vascular Technology of Great Britain and Ireland

The National School of Healthcare Science Themed Board reviewed the MSc Clinical Science (Cardiac, Vascular, Respiratory and Sleep Sciences) Curriculum on 24 January 2013 and their feedback has also shaped the final publication.

**Modernising Scientific Careers Professional Advisors**  
Mrs Christine Burke  
Mr Keith Johnston  
Mrs Theresa Fail

**National School of Healthcare Science Professional Lead**  
Mrs Theresa Fail
Appendix 2: Programme Amendments

This section lists the programme amendments following first publication.

Amendments – March 2013

These amendments apply to trainees commencing STP in the academic year 2013/14.

1. A generic introduction to all STP MSc Clinical Science programmes has been added.
2. In order to improve the alignment to QAA level 7 the word ‘understand’ has been replaced with an appropriate verb from Bloom’s Taxonomy for the Knowledge domain.
3. The generic module Healthcare Science has been renamed ‘Introduction to Healthcare Science, Professional Practice and Clinical Leadership’.
4. The generic modules Healthcare Science (which incorporates Professional Practice) and Research Methods have been revised and updated.
5. The Research Project has been revised and all students are expected to complete a single 60-credit research project spanning Years 2 and 3, see relevant section.
6. Good Scientific Practice (GSP) sets out for the healthcare science profession and the public the standards of behaviour and practice that must be achieved and maintained in the delivery of work activities, the provision of care and personal conduct. GSP has been added in the Appendices of each curricula and aspects of professionalism strengthened to reflect areas such as the need to ensure the shared nature of clinical decision making.
7. The learning outcomes related to ‘Personal Attitudes and Behaviours’ now appear in the Professional Practice section of this document but apply to all modules.
8. In Cardiac Science and Respiratory and Sleep Science the learning outcomes have been grouped under sub headings in some modules and in places two learning outcomes have been combined into a single learning outcome to reduce duplication.

The new version is called MSc_CCVRS_Final_Version_3.0_for_2013-14
For any queries regarding this change please email msc.hee@nhs.net

Amendments – December 2013

An error in the labelling of the rotations on page 40 was identified and has been corrected. The correct instructions are:

Trainees in Cardiac, Vascular, or Respiratory and Sleep Science complete rotations A, C, D and E, and trainees in Critical Care Science rotations A, B, C and F.

The new version is called MSc_CCVRS_Final_Version_3.1_for_2013-14
For any queries regarding this change please email msc.hee@nhs.net
Amendments – March 2014

Amendment to Critical Care Science Module 4: Diagnostic and Therapeutic Techniques in Critical Care (CCS-4)

Following feedback one work based learning outcome was amended.

Page 107: Work Based Learning Outcome 3
Set up and manage extracorporeal therapies related to mechanical ventilation (Extra Corporeal Membrane Oxygenation ECMO, CO₂ removal).

REPLACED WITH:

Set up and manage extracorporeal therapies related to mechanical ventilation (CO₂ removal).

The new version is called MSc_CCVRS_Final_Version_3.2_for_2013-14
For any queries regarding this change please email msc.hee@nhs.net
Appendix 3: Good Scientific Practice

Good Scientific Practice
Section 1: The purpose of this document
There are three key components to the Healthcare Science workforce in the UK:

1. Healthcare Science Associates and Assistants who perform a diverse range of task based roles with appropriate levels of supervision.

2. Healthcare Science Practitioners have a defined role in delivering and reporting quality assured investigations and interventions for patients, on samples or on equipment in a healthcare science specialty, for example Cardiac Physiology, Blood Sciences or Nuclear Medicine. They also provide direct patient care and more senior Healthcare Science Practitioners develop roles in specialist practice and management.

3. Healthcare Scientists are staff that have clinical and specialist expertise in a specific clinical discipline, underpinned by broader knowledge and experience within a healthcare science theme. Healthcare scientists undertake complex scientific and clinical roles, defining and choosing investigative and clinical options, and making key judgements about complex facts and clinical situations. Many work directly with patients. They are involved, often in lead roles, in innovation and improvement, research and development and education and training. Some pursue explicit joint academic career pathways, which combined clinical practice and academic activity in research, innovation and education.

This document sets out the principles and values on which good practice undertaken by the Healthcare Science workforce is founded.

Good Scientific Practice sets out for the profession and the public the standards of behaviour and practice that must be achieved and maintained in the delivery of work activities, the provision of care and personal conduct.

Good Scientific Practice uses as a benchmark the Health Professions Council (HPC) Standards of Proficiency and Standards of Conduct, Performance and Ethics, but expresses these within the context of the specialities within Healthcare Science, recognising that three groups of the workforce, Biomedical Scientists, Clinical Scientists and Hearing Aid Dispensers are regulated by the HPC. The aim is that the standards are accessible to the profession and understandable by the public.

Good Scientific Practice represents standards and values that apply throughout an individual’s career in healthcare science at any level of practice. The standards will be contextualised by the role within Healthcare Science that an individual undertakes. This means that the standards must be interpreted based on the role that an individual performs. For example, in supervised roles where individuals work within defined procedures, rather than autonomously, some standards will need to
be interpreted appropriately for the context of the specific role. There will, however, always be a requirement for an individual to work within the limits of their scope of practice and competence.

Students and trainees will be expected to be working towards meeting the expectations set out in this document. However, if an individual is undertaking further training and development following qualification from a professional training programme, he or she will be expected to be able to meet the standards in this document within their scope of practice.

The standards have been used to support curriculum development and will be used to underpin the process of judging individual equivalence, particularly for emerging specialisms.

The standards have been divided into five domains. The domains of Good Scientific Practice detailed in section 2 are:

1. Professional Practice
2. Scientific Practice
3. Clinical Practice
4. Research and development
5. Clinical Leadership

Section 2: The domains of Good Scientific Practice

Domain 1: Professional Practice

All patients and service users are entitled to good standards of professional practice and probity from the Healthcare Science workforce including the observance of professional codes of conduct and ethics. In maintaining your fitness to practice as a part of the Healthcare Science workforce, you must:

1.1 Professional Practice

1.1.1 Make the patient your first concern
1.1.2 Exercise your professional duty of care
1.1.3 Work within the agreed scope of practice for lawful, safe and effective healthcare science
1.1.4 Keep your professional, scientific, technical knowledge and skills up to date
1.1.5 Engage fully in evidence based practice
1.1.6 Draw on appropriate skills and knowledge in order to make professional judgements
1.1.7 Work within the limits of your personal competence
1.1.8 Act without delay on concerns raised by patients or carers or if you have good reason to believe that you or a colleague may be putting people at risk
1.1.9 Never discriminate unfairly against patients, carers or colleagues
1.1.10 Treat each patient as an individual, respect their dignity and confidentiality and uphold the rights, values and autonomy of every service user, including
their role in the diagnostic and therapeutic process and in maintaining health and well-being.

1.1.11 Respond constructively to the outcome of audit, appraisals and performance reviews, undertaking further training where necessary

1.2 Probity

1.2.1 Make sure that your conduct at all times justifies the trust of patients, carers and colleagues and maintains the public’s trust in the scientific profession

1.2.2 Inform the appropriate regulatory body without delay if, at any time, you have accepted a caution, been charged with or found guilty of a criminal offence, or if any finding has been made against you as a result of fitness to practice procedures, or if you are suspended from a scientific post, or if you have any restrictions placed on your scientific, clinical or technical practice

1.2.3 Be open, honest and act with integrity at all times, including but not limited to: writing reports, signing documents, providing information about your qualifications, experience, and position in the scientific community, and providing written and verbal information to any formal enquiry or litigation, including that relating to the limits of your scientific knowledge and experience

1.2.4 Take all reasonable steps to verify information in reports and documents, including research

1.2.5 Work within the Standards of Conduct, Performance and Ethics set by your profession

1.3 Working with colleagues

1.3.1 Work with other professionals, support staff, service users, carers and relatives in the ways that best serve patients’ interests

1.3.2 Work effectively as a member of a multi-disciplinary team

1.3.3 Consult and take advice from colleagues where appropriate

1.3.4 Be readily accessible when you are on duty

1.3.5 Respect the skills and contributions of your colleagues

1.3.6 Participate in regular reviews of team performance.

1.4 Training and developing others

1.4.1 Contribute to the education and training of colleagues

1.4.2 If you have responsibilities for teaching, develop the skills, attitudes and practices of a competent teacher

1.4.3 Ensure that junior colleagues and students are properly supervised

1.4.4 Support colleagues who have difficulties with performance, conduct or health

1.4.5 Share information with colleagues to protect patient safety

1.4.6 Provide work-based development for colleagues to enhance/improve skills and knowledge

Domain 2: Scientific Practice
As a part of the Healthcare Science workforce, you will keep your scientific and technical knowledge and skills up to date to effectively:

2.1 Scientific Practice

2.1.1 Develop investigative strategies/procedures/processes that take account of relevant clinical and other sources of information
2.1.2 Provide scientific advice to ensure the safe and effective delivery of services
2.1.3 Undertake scientific investigations using qualitative and quantitative methods to aid the screening, diagnosis, prognosis, monitoring and/or treatment of health and disorders appropriate to the discipline
2.1.4 Investigate and monitor disease processes and normal states
2.1.5 Provide clear reports using appropriate methods of analysing, summarising and displaying information
2.1.6 Critically evaluate data, draw conclusions from it, formulate actions and recommend further investigations where appropriate

2.2 Technical Practice

2.2.1 Provide technical advice to ensure the safe and effective delivery of services
2.2.2 Plan, take part in and act on the outcome of regular and systematic audit
2.2.3 Work within the principles and practice of instruments, equipment and methodology used in the relevant scope of practice
2.2.4 Demonstrate practical skills in the essentials of measurement, data generation and analysis
2.2.5 Assess and evaluate new technologies prior to their routine use
2.2.6 Identify and manage sources of risk in the workplace, including specimens, raw materials, clinical and special waste, equipment, radiation and electricity.
2.2.7 Apply principles of good practice in health and safety to all aspects of the workplace
2.2.8 Apply correct methods of disinfection, sterilisation and decontamination and deal with waste and spillages correctly.
2.2.9 Demonstrate appropriate level of skill in the use of information and communications technology

2.3 Quality

2.3.1 Set, maintain and apply quality standards, control and assurance techniques for interventions across all clinical, scientific and technological activities
2.3.2 Make judgements on the effectiveness of processes and procedures
2.3.3 Participate in quality assurance programmes
2.3.4 Maintain an effective audit trail and work towards continuous improvement

Domain 3: Clinical Practice
As a part of the Healthcare Science workforce, you will keep your clinical skills up to date and undertake the clinical duties appropriate to your role in order to effectively:

3.1 Clinical Practice

3.1.1 Ensure that you and the staff you supervise understand the need for and obtain relevant consent before undertaking any investigation, examination, provision of treatment, or involvement of patients and carers in teaching or research

3.1.2 Ensure that you and the staff you supervise maintain confidentiality of patient information and records in line with published guidance

3.1.3 Ensure that you and your staff understand the wider clinical consequences of decisions made on your actions or advice

3.1.4 Demonstrate expertise in the wider clinical situation that applies to patients who present in your discipline

3.1.5 Maintain up to date knowledge of the clinical evidence base that underpins the services that you provide and/or supervise and ensure that these services are in line with the best clinical evidence

3.1.6 Plan and determine the range of clinical/scientific investigations or products required to meet diagnostic, therapeutic, rehabilitative or treatment needs of patients, taking account of the complete clinical picture

3.1.7 Plan and agree investigative strategies and clinical protocols for the optimal diagnosis, monitoring and therapy of patients with a range of disorders

3.1.8 Ensure that detailed clinical assessments are undertaken and recorded using appropriate techniques and equipment and that the outcomes of these investigations are reviewed regularly with users of the service

3.1.9 Ensure the provision of expert interpretation of complex and or specialist data across your discipline in the context of clinical questions posed

3.1.10 Undertake and record a detailed clinical assessment using appropriate techniques and equipment

3.1.11 Provide specialised clinical investigation and/or analysis appropriate to your discipline

3.1.12 Provide interpretation of complex and/or specialist data in the context of the clinical question posed

3.1.13 Provide clinical advice based on results obtained, including a diagnostic or therapeutic opinion for further action to be taken by the individual directly responsible for the care of the patient

3.1.14 Provide expert clinical advice to stakeholders in order to optimise the efficiency and effectiveness of clinical investigation of individuals and groups of patients

3.1.15 Prioritise the delivery of investigations, services or treatment based on clinical need of patients

3.1.16 Represent your discipline in multidisciplinary clinical meetings to discuss patient outcomes and the appropriateness of services provided

3.1.17 Ensure that regular and systematic clinical audit is undertaken and be responsible for modifying services based on audit findings.

3.2 Investigation and reporting
3.2.1 Plan and conduct scientific, technical, diagnostic, monitoring, treatment and therapeutic procedures with professional skill and ensuring the safety of patients, the public and staff
3.2.2 Perform investigations and procedures/design products to assist with the management, diagnosis, treatment, rehabilitation or planning in relation to the range of patient conditions/equipment within a specialist scope of practice
3.2.3 Monitor and report on progress of patient conditions/use of technology and the need for further interventions.
3.2.4 Interpret and report on a range of investigations or procedures associated with the management of patient conditions/equipment

Domain 4: Research, Development and Innovation

As part of the Healthcare Science workforce, research, development and innovation are key to your role. It is essential in helping the NHS address the challenges of the ageing population, chronic disease, health inequalities and rising public expectations of the NHS. In your role, you will undertake the research, development and innovation appropriate to your role in order to effectively:

4.1 Research, Development and Innovation

4.1.1 Search and critically appraise scientific literature and other sources of information
4.1.2 Engage in evidence-based practice, participate in audit procedures and critically search for, appraise and identify innovative approaches to practice and delivery of healthcare
4.1.3 Apply a range of research methodologies and initiate and participate in collaborative research
4.1.4 Manage research and development within a governance framework
4.1.5 Develop, evaluate, validate and verify new scientific, technical, diagnostic, monitoring, treatment and therapeutic procedures and, where indicated by the evidence, adapt and embed them in routine practice
4.1.6 Evaluate research and other available evidence to inform own practice in order to ensure that it remains at the leading edge of innovation.
4.1.7 Interpret data in the prevailing clinical context
4.1.8 Perform experimental work, produce and present results
4.1.9 Present data, research findings and innovative approaches to practice to peers in appropriate forms
4.1.10 Support the wider healthcare team in the spread and adoption of innovative technologies and practice

Domain 5: Clinical Leadership

All patients and service users have a right to expect that Healthcare Science services efficiently and effectively managed to meet service needs. As a leader in Healthcare Science, you will seek to effectively:

5.1 Leadership
5.1.1 Maintain responsibility when delegating healthcare activities and provide support as needed
5.1.2 Respect the skills and contributions of your colleagues
5.1.3 Protect patients from risk or harm presented by another person’s conduct, performance or health
5.1.4 Treat your colleagues fairly and with respect
5.1.5 Make suitable arrangements to ensure that roles and responsibilities are covered when you are absent, including handover at sufficient level of detail to competent colleagues
5.1.6 Ensure that patients, carers and colleagues understand the role and responsibilities of each member of the team
5.1.7 Ensure that systems are in place through which colleagues can raise concerns and take steps to act on those concerns if justified
5.1.8 Ensure regular reviews of team performance and take steps to develop and strengthen the team
5.1.9 Take steps to remedy any deficiencies in team performance
5.1.10 Refer patients to appropriate health professionals
5.1.11 Identify and take appropriate action to meet the development needs of those for whom you have management, supervision or training responsibilities
5.1.12 Act as an ambassador for the Healthcare Science community

*Good Scientific Practice AHCS V.2 Final*

*September 2012*
**Appendix 4: Glossary**

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Clinical experiential learning</td>
<td>The cyclical process linking concrete experience with abstract conceptualisation through reflection and planning.</td>
</tr>
<tr>
<td>Clinical experiential learning outcomes</td>
<td>The activities that the trainee will undertake to enable and facilitate their learning in the workplace.</td>
</tr>
<tr>
<td>Competence</td>
<td>The ability of an individual to perform a role consistently to required standards combining knowledge, understanding, skills and behaviour.</td>
</tr>
<tr>
<td>Competence statements</td>
<td>Active and outcome-based statements that provide a further breakdown of the Learning Outcomes – reflecting what the trainee will be able to do in the workplace at the end of the programme. Each competence should be linked back to the numbered Learning Outcomes.</td>
</tr>
<tr>
<td>Component</td>
<td>An indication of the type of module within a learning guide, i.e. rotational, specialist, or elective.</td>
</tr>
<tr>
<td>Curricula</td>
<td>An outline of the expected educational outcomes across a subject area. The learning that is expected to take place during the Scientist Training Programme described in terms of knowledge, skills and attitudes.</td>
</tr>
<tr>
<td>Division</td>
<td>A high-level description of an area of practice within healthcare science. There are three divisions: Life Sciences, Physical Sciences, and Biomedical Engineering and Physiological Sciences.</td>
</tr>
<tr>
<td>Domains of learning</td>
<td>Cognitive (knowledge and intellectual skills), affective (feelings and attitudes), interpersonal (behaviour and relationships with others) and psychomotor (physical skills).</td>
</tr>
<tr>
<td>Feedback</td>
<td>Specific information about the comparison between a trainee’s observed performance and a standard, given with the intent to improve the trainee’s performance (van de Ridder JMM, Stokking KM, McGaghie WC and ten Cate OT. What is feedback in clinical education? Medical Education 2008: 42: 189–197).</td>
</tr>
<tr>
<td>Good Scientific Practice</td>
<td>Non-statutory guidance on the minimum requirements for good practice for the healthcare science workforce.</td>
</tr>
<tr>
<td>Host department</td>
<td>The department that is responsible for the three-year training programme and in which the training officer is based.</td>
</tr>
<tr>
<td>Job</td>
<td>A specific definition of the work activities, requirements and skills required to undertake work activities within a local context. This differs from a role – see below.</td>
</tr>
<tr>
<td>Key learning outcome</td>
<td>A defined learning outcome linked to relevant competence(s) within the workplace Learning Guide.</td>
</tr>
<tr>
<td>Knowledge and understanding</td>
<td>The knowledge and understanding that must be applied in the workplace to achieve the stated competence.</td>
</tr>
<tr>
<td>Learning framework</td>
<td>The specification for work based learning contained</td>
</tr>
<tr>
<td><strong>Learning module</strong></td>
<td>A distinct set of learning outcomes and competences that form part of a programme. Modules may be rotational, specialist, elective, or professional practice and can be combined to meet the needs of specific programmes.</td>
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<tr>
<td><strong>Learning outcome</strong></td>
<td>A high-level, outcome-based statement that describes what a trainee will be able to do at the end of the module.</td>
</tr>
<tr>
<td><strong>Mentoring</strong></td>
<td>Mentoring is <em>a process in which a trainer (mentor) is responsible for overseeing the career and development of the trainee</em>. The emphasis is therefore on the relationship (rather than the activity).</td>
</tr>
<tr>
<td><strong>Module aim</strong></td>
<td>The overall objective of a work based learning module – defining the intended learning achievements of the trainee. The aim works together with the ‘Scope’ statement to define the overall objectives and scope of the module.</td>
</tr>
<tr>
<td><strong>Module scope</strong></td>
<td>A statement within work based learning modules that defines the range/limits of the learning undertaken by the trainee in a module – patients/investigations/equipment/modalities, etc.</td>
</tr>
<tr>
<td><strong>National Occupational Standards</strong></td>
<td>Nationally recognised standards of expected workplace performance and level of competence for a role. The standards are outcome-based, defining what the role holder should be able to do, as well as what they must know and understand to demonstrate competent work performance. National Occupational Standards are supported by nationally agreed frameworks of expected attitudes, behaviour and skills.</td>
</tr>
<tr>
<td><strong>Practical skill</strong></td>
<td>A cognitive, psychomotor, physical, or communicative ability that supports performance of the required role.</td>
</tr>
<tr>
<td><strong>Programme</strong></td>
<td>The package of learning, teaching assessment and quality assurance leading to an award.</td>
</tr>
<tr>
<td><strong>Provider</strong></td>
<td>An organisation that delivers required training and learning activities to specified quality assurance requirements.</td>
</tr>
<tr>
<td><strong>Role</strong></td>
<td>A collection of functions undertaken in the workplace that represent the main broad areas of work for all similar workers at national level. A role differs from a job, the latter being defined specifically for a local context.</td>
</tr>
<tr>
<td><strong>Specialism</strong></td>
<td>A focused area of practice within a theme of healthcare science.</td>
</tr>
<tr>
<td><strong>Trainer</strong></td>
<td>A qualified individual who provides learning and development support for trainees.</td>
</tr>
<tr>
<td><strong>Theme</strong></td>
<td>A cluster of related specialisms within a division of healthcare science.</td>
</tr>
</tbody>
</table>
| **Work based learning** | Learning that takes place in a real work setting and involves the application of academic learning to real
<table>
<thead>
<tr>
<th><strong>Work performance</strong></th>
<th>The requirements of satisfactory and consistent demonstration of competence in specified functions for a work role.</th>
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<tbody>
<tr>
<td><strong>Workplace</strong></td>
<td>A real work setting in which the trainee can apply learning.</td>
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