Graduate Apprenticeship Guidance Supplement

HERIOT WATT UNIVERSITY

BSc (Hons) Software Development for Business

Academic Session 2022-23

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1. School and Discipline Information

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2. Welcome and Introduction

2.1 Welcome from Head of the School

The School of Mathematical and Computer Science welcomes you warmly to our Graduate Apprenticeship scheme. We are looking forward to the contribution you will make to our School and to shaping this programme. We will help you achieve your potential and make the most of the opportunities the programme will offer you.

On behalf of everyone in the School, I wish every success in your work and your studies.

Professor Beatrice Pelloni Head of School

2.2 Welcome from Academic Head of Computer Science

We are very proud of our Computer Science heritage here at Heriot-Watt University and were the first university in Scotland to launch a BSc degree in Computer Science back in 1966. Today within Computer Science we have a very strong portfolio of undergraduate and postgraduate degree programmes. We pride ourselves on our research-led teaching where advanced courses reflect the many research strengths of the department.

As a student on the Graduate Apprenticeship programme in BSc Software Development for Business, you will be part of an increasingly important, dynamic, and multi-disciplinary field to help address many of society's challenges of the future. We have a long history of working closely with industry, and we are looking forward to developing even closer links through this programme. We believe that the Graduate Apprenticeship initiative will provide unique benefits to all those involved - but most importantly to you as you progress towards your degree through work-based learning.

My colleagues and I are looking forward to working with you and supporting you in your studies. I hope that you enjoy your time here at Heriot-Watt.

Professor Jurriaan Hage
Head of Department

2.3 The School of Mathematical and Computer Sciences (MACS)

The School of Mathematical and Computer Sciences (MACS) is comprised of three departments, Computer Science (CS), Mathematics (Maths) and Actuarial Mathematics and Statistics (AMS), based at our three campuses: Edinburgh, Dubai and Malaysia. The BSc Software Development for Business, Graduate Level Apprenticeship is a CS programme delivered at the Edinburgh Campus.

2.3.1 School Student Website

This website provides useful information for all current MACS students for each stage of your journey from Enrolment through to Graduation. You will find documentation about your chosen programme and courses, important dates throughout the year, core academic staff and links to useful resources. http://www.macs.hw.ac.uk/students/

2.3.2 Examinations for Taught Courses

It is the apprentice's responsibility to check all relevant examination timetables (including resits) on the Registry web page https://www.hw.ac.uk/students/studies/examinations.htm

Should you be required to be re-assessed in any examinations, you *must* make yourself available to take them. All exams must be taken at the Edinburgh Campus.

You can find past exam papers from 2019-20 onwards in the relevant area for each course on Canvas (our virtual learning environment). Past exam papers from 2016-2019 for taught F2 courses can be found at: https://www.macs.hw.ac.uk/students/cs/past-exam-papers/

2.3.3 Prizes

University Prizes, Years 1, 2 & 3 (£100)

For outstanding merit (In practice an average mark of at least 70% is regarded as the minimum standard). Available to students on any undergraduate course in the Department of Computer Science. There is one prize per academic year per year of study.

Vindhya Liyanage Citizenship Award (£100)

Awarded to a student, or group of students, who have shown exceptional citizenship in their 1st year of study within the Department of Computer Science.

2.3.4 Miscellaneous

Lockers and buildings access cards

Lockers for use by students and apprentices are available at a number of sites in the Earl Mountbatten Building. They are allocated for the duration of each academic year on a first-come, first-served basis. Keys for lockers in the EM Building are available at School's Office EM1.25 for a deposit of £10. In addition, final year students may request extended access to enter the Earl Mountbatten Building until 10pm on weekdays and during the weekends.

Mail

Mail (internal and external) to students is delivered to pigeonholes on the first floor of the Earl Mountbatten Building, inside the School Office (EM1.25). Apprentices are advised to check these regularly.

3. BSc (Hons) Software Development for Business GA Programme

3.1 Programme Description

The BSc (Hons) Software Development programme consists of 8 courses per full academic year. Each course is worth 15 Credits, totalling 120 Credits per year. There are three types of course delivery modes, as below. This blended academic and work-based learning ensures apprentices enjoy the best of both academic and commercial worlds.

Taught courses: this type of course will be delivered on-campus (or virtually, depending on government restrictions) via standard methods where apprentices will enjoy campus facilities and mixed with our mainstream students;

Work-based Blended Learning (WBL) courses: course materials will be delivered on-line (through the entire academic year), assisted by on-campus hands-on lab sessions and tutorials, where appropriate. Apprentices' progress will be monitored and assessed on-line and/or via e-assessment; face-to-face and virtual meetings are available, when needed;

Industrial Project (IP) courses: such courses require larger, real/realistic industry-specific project implementation. Normally, they are completed in Semester 3.

3.2 Entry Requirements

Year 1:

- SQA Highers at ABBB including Computing or equivalent
- A-Levels at BBB including Computing or equivalent
- Int. Baccalaureate 28 points
- BTEC Extended Diploma (QCF) Level 3 at DDM
- Foundation Apprenticeship in Software Development in conjunction with SQA Highers at BBB
- A combination of qualifications totalling 96 SCQF credits at level 6, or Minimum 106 UCAS points, including suitable Mathematics

Year 2:

- SQA Advanced Highers at BBB including Computing and excellent SQA Highers or Scottish Baccalaureate;
- A-Levels at ABB including Computing;
- Int. Baccalaureate 30 points including Computing at Higher Level 6.
- HNC in a relevant subject area (or a suitable Modern Apprenticeship) with A in graded unit.
- BTEC Extended Diploma (QCF) Level 3 at DDM including sufficient Computing.
- A combination of qualifications totalling 96 SCQF credits at level 7 including suitable Mathematics

Each candidate will be assessed for entry individually and other forms of prior learning or experience will be taken into account if a candidate doesn't hold the exact qualifications listed here.

Advanced entry to second (or third year in extraordinary cases) may be possible if the

candidate possesses more advanced prior learning or experience. Interest in advanced entry should be communicated to the Programme Director during the application process. Those entering at Stage 2 are expected to be proficient in a high-level programming language, Java is our preference. Direct entrants to Stage 2 must have appropriate background in object-oriented software design, (web) programming and database technologies. Students from FE Colleges who meet the established conditions for articulation into Stage 2 of the BSc in Computer Systems programme will also satisfy the conditions for articulation into Stage 2 of the SDB Graduate Apprenticeship programme. Please note that advanced entry is at the discretion of the University.

3.3 Educational Aims of the Programmes

The programmes aim to produce BSc (Hons) graduates who:

- have a solid foundation in Software Development and are proficient in applying programming techniques to diverse applications;
- are able to operate in a team and in a multidisciplinary context;
- have excellent problem solving skills;
- have the ability to develop innovative solutions to society's practical needs;
- have developed the professional competencies of software engineers.

3.4 Programme Delivery

3.4.1 Contact Days

The specific contact days that the apprentices will be released to attend the university are described in the table below:

		Year			
		1	**2**	**3**	**4**
Semester	**1**	Friday	Monday	Monday	Friday
	2	Friday	Monday	Monday	Friday
	3	Friday	Monday	Monday	Friday

Semesters 1 and 2 form part of the traditional academic year (September – December, January – March/May) and as such apprentices will be required to attend university every week on their contact day.

Semester 3 takes place during the summer months (May – August) and as such has a more relaxed attendance requirement. Tutorial classes and ad-hoc lectures will be held (where required by the apprentices) to support the directed learning aspects of some courses, at most for six weeks. On the 'off-week' contact days extra sessions may be arranged to help apprentices to complete a specific piece of work should they have fallen behind for any reason or be experiencing difficulties.

3.4.2 Individual Self-Study Time

In addition to the contact day at the university, apprentices require approximately 0.5 days a week in the workplace to engage in work-based learning activities and undertake courses taught by directed learning.

3.5 Progression and Graduation

The minimum number of credits and grades required to progress through each stage of the programme are as follows:

- Stage 1 to 2 - 120 credits and minimum D grade in all courses
- Stage 2 to 3 – 240 credits and minimum D grade in all courses
- Stage 3 to 4 – 360 credits, an overall average of 50% in the first attempt and minimum D grade in all courses

In years 1, 2 and 3 if an apprentice fails one of the Work-based Blended Learning (WBL) courses they will be given the opportunity to retake the course, typically to be performed in the following semester. In cases where the course is a pre-requisite for another Work-Based Learning course, the start of the latter will be delayed until the re-assessment of the former has been successfully completed. In Year 3, re-assessment is for credit only and the apprentice's overall average (which accounts for 20% of the final degree) cannot improve unless there is a mitigating circumstance. There are no reassessment opportunities for courses in Year 4.

Honours degree classification is determined by performance in:

- Stage 3 averaged over all level 9 courses (20%) at the first attempt;
- The assessed courses in Stage 4 (50%);
- The individual dissertation project in Stage 4 (30%). The BSc award gradings are:

First class	1st	Grade A (average mark of 70% or more for qualifying courses)
Second class (Upper division)	2:1	Grade B (average mark of 60% - 69% for qualifying courses)
Second class (Lower division)	2:2	Grade C (average mark of 50% - 59% for qualifying courses)
Third class	3rd	Grade D (average mark of 40% - 49% for qualifying courses)
Ordinary	Ord	Grade E

The University operates the Heriot Watt Assessment and Progression System (HAPS) which specifies minimum progression requirements. Schools have the option to apply progression requirements above the minimum University requirement, which are approved by the Studies Committees. Students should refer to the programme specific information on progression requirements. You can also contact your Personal Tutor for information.

3.6 BSc Software Development - Programme Structure

Link to BSc Software Development Programme Overview and Course Descriptors: https://www.macs.hw.ac.uk/students/cs/ug-programmes/bsc-software-development-for-business/

<table>
<tr><th colspan="3">YEAR 1 – Mandatory Courses</th></tr>
<tr><th>Semester 1</th><th>Semester 2</th><th>Semester 3</th></tr>
<tr><td>Software Development 1 (F27SA)[1]</td><td>Software Development 2 (F27SB)[1]</td><td rowspan="2">Industrial Project: Software Development Methods (F27IP)</td></tr>
<tr><td>Intro to Interaction Design (F27ID)</td><td>Enterprise and its Business Environment (C17GE)</td></tr>
<tr><td colspan="3">Introduction to Computer Systems (F27CX)</td></tr>
<tr><td colspan="3">Industrial Praxis (F27IX)</td></tr>
<tr><td colspan="3">Internet Technologies 1 (F27IR)</td></tr>
</table>

<table>
<tr><th colspan="3">YEAR 2 – Mandatory Courses</th></tr>
<tr><th>Semester 1</th><th>Semester 2</th><th>Semester 3</th></tr>
<tr><td>Intro to Data Structures and Algorithms (F28SG)[1]</td><td rowspan="2">Data Structures and Algorithms (F28DA)[1]</td><td rowspan="2"></td></tr>
<tr><td>User-Centred Experimental Design (F28ED)[1]</td></tr>
<tr><td colspan="3">Programming Languages (F28LL)</td></tr>
<tr><td colspan="3">Database Management (F28DD)</td></tr>
<tr><td colspan="3">Introduction to Software Engineering(F28SX)</td></tr>
<tr><td colspan="3">Internet Technologies 2 (F28IR)</td></tr>
<tr><th colspan="3">YEAR 2 – Optional Courses (CHOOSE ONE)</th></tr>
<tr><th>Semester 1</th><th>Semester 2</th><th>Semester 3</th></tr>
<tr><td></td><td>Hardware-Software Interface (F28HS)[1]</td><td>Industrial Project: Structured Programming (F28JP)</td></tr>
</table>

[1] Course assessed via examination (in whole or in part)

<table>
<tr><th colspan="3">YEAR 3 – Mandatory Courses</th></tr>
<tr><th>Semester 1</th><th>Semester 2</th><th>Semester 3</th></tr>
<tr><td>Artificial Intelligence and Intelligent Agents (F29AI)[2]</td><td>Accounting for Managers (C38GA)[2]</td><td rowspan="2">Industrial Project: Software Quality (F29IP)</td></tr>
<tr><td colspan="2">Operations Management (C18GO)</td></tr>
<tr><td colspan="3">Software Engineering (F29SY)</td></tr>
<tr><td colspan="3">Professional Development (F29RD)</td></tr>
<tr><td colspan="3">Digital Enterprise Services (F29DS)</td></tr>
<tr><td colspan="3">Computer Network and Communications (F29NC)</td></tr>
</table>

<table>
<tr><th colspan="3">YEAR 4 – Mandatory Courses</th></tr>
<tr><th>Semester 1</th><th>Semester 2</th><th>Semester 3</th></tr>
<tr><td rowspan="3">Industrial Project: Research Methods and Requirements Engineering (F20PP)</td><td colspan="2">Industrial Project: Design and Implementation (F20PQ)</td></tr>
<tr><td>Project Management (C19GP)</td><td rowspan="3">Industrial Project: Testing and Presentation (F20PR)</td></tr>
<tr><td>Mobile Communications and Programming (F20MX)</td></tr>
<tr><td>Computer Network Security (F20CN)[2]</td><td>Data Mining and Machine Learning (F20DX)</td></tr>
<tr><th colspan="3">YEAR 4 – Optional Courses (choose one)</th></tr>
<tr><th>Semester 1</th><td colspan="2" rowspan="3">These three optional courses are offered under the following understanding:
• By default, students are automatically enrolled in C19GS and this is the expected path for most students.
• F20GA and F20RO are not work-based learning courses. If either of these courses is chosen the employer must allow the student time to attend their chosen course on the dates and times scheduled for regular CS students, which may be different from the usual SDB contact day (see page 6).
• F20GA and F20RO typically require 10 hours per week of teaching and self-study per course during termtime.
• F20GA and F20RO require a high-level knowledge of introductory concepts in robotics and programming or software programming.
• If a student wishes to take F20GA or F20RO then their choice must first be formally approved both by their employer, their academic tutor and the Programme Director.</td></tr>
<tr><td>Strategic Management (C19GS)</td></tr>
<tr><td>3D Graphics and Animation (F20GA)

Intelligent Robotics (F20RO)</td></tr>
</table>

[2] Course assessed via examination (in whole or in part)

3.7 Course Catalogue

Year 1:

- F27SA Software Development 1 (15 Credits)
  Objects and classes; Class definitions, fields, constructors, methods, parameters; Selection and iteration; Object interaction: main method, creating and using class instances; Grouping objects, collection classes, iterators, arrays; Library classes; Documentation; Testing and debugging.
- F27SB Software Development 2 (15 Credits)
  Inheritance, hierarchies, subclasses, polymorphism, static and dynamic types, overriding, dynamic method lookup; Designing classes, coupling, cohesion, abstraction, modularisation, types; Abstract classes, abstract methods, interfaces; State machines & state diagrams; GUIs and event handling, Error-handling, defensive programming, exceptions, assertions, JUnit tests; Collection classes.
- F27CX Introduction to Computer Systems (15 Credits)
  Hardware components, peripherals, memory & CPU; Boolean algebra; Low-level information representation; Introductory assembly language programming; Operating systems and concurrency; Language compilers; Linux shell scripting.
- F27IR Internet Technologies 1 (15 Credits)
  Web, Internet and Information architectures; HTTP protocols and methods; Human-computer interaction and user experience fundamentals; DOM programming interface; data storage and exchange formats; HTML semantics, storage and APIs; CSS fundamentals and design; JavaScript (JS) fundamentals, DOM manipulation and events handling with JS. Mobile-first design principles.
- F27IX Industrial Praxis (15 Credits)
  Writing reports; Sources and referencing; Group presentation; Understanding and avoiding plagiarism; Current departmental research; Exploration of the departmental computer system; Study skills.
- F27ID Introduction to Interaction Design (15 Credits)
  Interaction design lifecycles; User interface design patterns; Problem spaces; Conceptual models; Prototyping; user requirements; User experience; Accessibility.
- C17GE Enterprise and its Business Environment (15 Credits)
  Business plans; The marketing function; The entrepreneur; Innovation; The human element; Operations, logistics and the value chain.
- F27IP Industrial Project: Software Development Methods (15 Credits)
  Modern software architecture and design principles; Legacy systems and mitigations; Software development lifecycle; Deployment, maintenance, continuous integration; System configuration, release management and version control; Virtual machines for development and deployment; Industrial project development, scoping, design, planning, requirements engineering, implementation, software testing and evaluation, and critical assessment.

Year 2:

- F28SG Introduction to Data Structures & Algorithms (15 Credits)
  Static structures, arrays; Linear techniques, search, delete, update; Dynamic structures, stacks & queues, Recursive techniques, linear recursion, accumulation recursion; Sorting & searching e.g. binary search, linear sorting, divide and conquer sorting; Linked structures, lists and trees; Introductory complexity & "big O" notation; Introduction to parallelism and concurrency.
- F28DA Data Structures and Algorithms (15 Credits)
  Advanced trees; String processing; Simple cryptography; Graphs; Hash tables; Algorithm and data structure choice, design and deployment.
- F28DD Database Management Systems (15 Credits)
  Relational algebra; Relational database model design, entities, attributes and relationships; Relational queries and SQL; Normalisation and denormalization; Queries and query optimisation; Transactions; Big data; Non-relational databases; Emerging database trends; Work-based database project.
- F28IR Internet Technologies 2 (15 Credits)
  Structured and procedural programming best practices; Server environment programming (e.g. node.js) and database integration (SQL and noSQL); Sessions, web storage and cookies; Asynchronous processing; Web services and microservices; Productive programming (e.g. agile, MVC); Distributed development and web development with virtual machines (e.g. Dockr, VirtualBox) and software release tools; Performance and scalability; Security.
- F28LL Programming Languages (15 Credits)
  History of programming languages, language syntax, semantics, implementation (e.g., compiler, interpreter, virtual machine); industrially used paradigms and languages; language concepts and features; Programming using key concepts, features, and paradigms in industrially used languages (e.g., Python).
- F28SX Introduction to Software Engineering (15 Credits)
  Software process models; Architectural styles; Design methods and associated notations – including function-oriented, object-oriented and component-based design; Design patterns; Software development life-cycle, requirements engineering, validation and verification (testing).
- F28ED User-Centred Experimental Design (15 Credits)
  Ethics of conducting experiments; Working with users; Experimental design; Hypothesis testing; Usability testing; Basic descriptive and inferential statistics; Qualitative analysis.

Year 2 Optional Courses:

- F28HS Hardware-Software Interfaces (15 Credits)
  Assembler programming; C programming; Advanced computer architecture issues impacting software performance; Operating system interfaces for low-level software; Device handling, interrupts, BIOS; Embedded systems programming; Resource-conscious programming.
- F28JP Industrial Project: Structured Programming (15 Credits)
  Structured programming concepts; System configuration process; Version control Software release management methods (e.g. itSMF, ITIL) and tools (e.g. Puppet, Plutora); Virtual machine (e.g. Docker, VirtualBox) usage for development, deployment, and scalability on distributed and Cloud systems; Software testing; Industrial project development (incl. project scope and design, planning, requirements engineering, system implementation, software testing and evaluation, and critical assessment

Year 3:

- F29DS Digital Enterprise Services (15 Credits)
  Introduction to monolithic and SOA architectures; Loosely coupled services, microservices; Cloud-native computing, applications on demand.; SaaS development methodologies and loosely coupled services design patterns; Containerisation, orchestration and continuous deployment; DevOps to deploy and operate API driven applications on the cloud.
- F29IP Industrial Project: Software Quality (15 Credits)
  Rigorous and organised software testing, Combinatorial models in software testing; Life cycle and levels of testing; Rapid prototyping and software quality; OO testing and procedural testing; Test-driven design, implementation and critical evaluation of software at the workplace; Data analytics and data-flow analysis techniques, tools and strategies used in industry.
- F29NC Computer Networks and Communications (15 Credits)
  OSI and Internet reference models; Link level communications, data transparency, error detection, sliding window protocols; Network layer protocols, IP, ICMP; Network routing, routers; Transport protocols, TCP, UDP; TCP; Congestion control.
- F29RD Professional Development (15 Credits)
  Professionalism and British Computer Society; Codes & standards, computer law and ethical decision making; Risks & threats, computer crime, viruses. Privacy & security, databases, biometrics. Safety-critical systems; Technology & society; Future directions.
- F29SY Software Engineering (15 Credits)
  Software project management, team work, project planning, costing, management and risk assessment; Use of industry-level standards for software development and documentation, change control and requirements traceability; Further study of software development tools and methodologies.
- F29AI Artificial Intelligence and Intelligent Agents (15 Credits)
  Search algorithms; Constraint satisfaction problems; Games; Logic, resolution, introductory logic programming; Knowledge representation; Goal- and data-driven reasoning; Practical rule-based programming; Overview of main fields of AI and in-depth view of one field (Vision, Learning, Knowledge Engineering); Autonomous agents; Applications and programming.
- C18GO Operations Management (15 Credits)
  Operations management and strategy; Social, environmental and economic performance; Product and service design; Process design; Facilities location, layout and flow; Supply network design; Capacity management; Inventory management; Planning and control; Lean synchronisation; Quality and operations improvement.
- C38GA Accounting for Managers (15 Credits)
  The role of accounting and finance in the business; Accounting skills; Financial statements such as balance sheet, cash flow and income statements; Budgeting and costing; Investment appraisal techniques; Financial risk management.
- C19GP Project Management (15 Credits)
  Projects, definition and scoping; Project breakdown structures and project organisation structures; Project scheduling, estimating and budgeting; project control and monitoring; Team-building and leadership; Project quality, risk management and contingency planning; Project closure.

Year 4:

- F20CN Computer Network Security (15 Credits)
  Basics of cryptography: principles & algorithms; Public-key encryption; Key Management; Proofcarrying code; Operating system security, concepts, security-enhanced Linux; X.800 network security model - attacks, mechanisms, services; Network service fundamentals - sockets, services, threads, base64 encoding; Digests; Digital signatures; X.509 certificates, certificate authorities and hierarchical trust models; Signed applets; Secure key exchange, secure web access.
- F20DX Data Mining and Machine Learning (15 Credits)
  Basic concepts and workflow, datasets and models, missing data, feature selection, supervised and unsupervised learning, evaluating models. Learning methods e.g. regression analysis, cluster analysis, decision trees, neural networks. Introduction to advanced methods e.g. ensemble methods and deep learning architectures. Applications e.g. recommender systems, market basket analysis, image processing.
- F20MX Mobile Communications and Programming (15 Credits)
  Fixed node IP routing; Mobile IP routing for wireless mobiles; Ad hoc networks; Security protocols; Small device characteristics - screen size, memory, power consumption, input mechanisms; Application development environments - Java APIs, C# and .NET.
- F20PP Industrial Project: Research Methods and Requirements Engineering (15 Credits)
  Requirements analysis of a software development project in the apprentice's industrial context; Researching current state of the art and industrial practice; Using library resources, Web and online database searching.
- F20PQ Industrial Project: Design and Implementation (15 Credits)
  Software and/or experimental design and its documentation; commercial practice in applied design of software, of relevance in the apprentice's industrial context.
- F20PR Industrial Project: Testing and Presentation (15 Credits)
  Testing and evaluation of software development projects in the apprentice's industrial context; Documenting software projects.

Year 4 Optional Courses:

- C19GS Strategic Management (GA) (15 Credits)
  Organisational focus; Strategic formulation; Strategic group mapping; Porter's Five Forces framework; Value chain analysis; Strategy implementation; Organisational design; Managing change; Change and culture; Corporate strategy and diversification.
- F20GA 3D Graphics and Animation (15 Credits)
  Concepts and practical introduction; Vertices, triangles, meshes, display lists and models; Hierarchical modelling and scene graphs; 2D and 3D transformations, homogeneous co-ordinates, matrices multiplication; Projection spaces; Instancing and tessellation; Materials, texture mapping and shading; Lighting, illumination, shadows; Rendering pipelines; Procedural and physical animations; Animation skeletons, poses, clips, skinning and blending; Tools, environments, coding, applications.

  Approval must be gained from the Programme Director prior to enrolment on this course

- F20RO Intelligent Robotics (15 Credits)
  Manipulators , geometry, kinematics, control and programming; Mobile robots, mapping, path planning and navigation; Behaviour based robotics, evolutionary, swarm and other bio-inspired robotics; Cognitive robotics, developmental robotics and human-robot interaction.
  Approval must be gained from the Programme Director prior to enrolment on this course