PROGRAMME STANDARDS :
COMPUTING

Agensi Kelayakan Malaysia
Malaysian Qualifications Agency

3rd Edition

This set of Programme Standards has been prepared to enhance the development of academic programmes in Computing and to ensure the quality of graduates. With this document, higher education providers will be able to provide quality education in Computing.

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FOREWORD

The Malaysian Qualifications Agency (MQA) has published numerous quality assurance documents, such as the Malaysian Qualifications Framework (MQF), Code of Practice for Programme Accreditation (COPPA), Code of Practice for Institutional Audit (COPIA), Code of Practice for TVET Programme Accreditation (COPTPA), Code of Practice for Programme Accreditation: Open and Distance Learning (COPPA: ODL), Standards, Programme Standards (PSs) and Guidelines to Good Practices (GGP), to ensure that the programmes offered by the Higher Education Providers (HEPs) in Malaysia meet international practices. It is imperative that these documents are read together with this PS for the development and delivery of Computing programmes in Malaysia.

This PS outlines sets of characteristics that describe the minimum levels of acceptable practices in Computing programmes based on the seven quality assurance areas: programme development and delivery, assessment of student learning, student selection and support services, academic staff, educational resources, programme management, and programme monitoring, review and continual quality improvement. Accordingly, the PS covers different levels of standards leading to the award of individual qualifications prescribed in the MQF 2nd Edition, ranging from the level of certificate (Level 3, MQF) to the level of Doctoral degree (Level 8, MQF).

This PS was developed by the MQA in collaboration with the Ministry of Higher Education. It represents the significant contribution from the panel members (as listed in **Appendix 1**) from both public and private HEPs and the industry, and in consultation with various HEPs, relevant government and statutory agencies, industries, alumni and students (see **Appendix 2**) through stakeholder workshops and online feedback. The PS developed reflects national and international best practices to ensure Computing graduates from the HEPs in Malaysia are on par with those in other countries.

That being said, this PS does not attempt to provide specific characteristics for Computing programmes, particularly those related to the framing of curricula and provision of educational resources. This PS encourages diversity and allows programme providers to be innovative in creating their niches. HEPs should ensure that they produce graduates that meet the current and future needs of the industry and at the same time, fulfil their obligations to society. Among others, this document includes statements of programme educational objectives and learning outcomes, which are intended to give clarity and are not intended to be adopted in a verbatim manner.

The MQA would like to express appreciation to all the panel members and various stakeholders for their valuable input, as well as all MQA officers who contributed to the development of this PS for Computing. It is hoped that this PS is beneficial to different stakeholders for the development of the competencies required of our students, for both job and higher education prospects.

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ABBREVIATIONS

COPIA	Code of Practice for Institutional Audit
COPPA	Code of Practice for Programme Accreditation
COPPA: ODL	Code of Practice for Programme Accreditation: Open and Distance Learning
COPTPA	Code of Practice for TVET Programme Accreditation
CPD	Continuous Professional Development
GGP	Guidelines to Good Practices
HEP	Higher Education Provider
MOOC	Massive Open Online Courses
MQA	Malaysian Qualifications Agency
MQF	Malaysian Qualifications Framework
NOSS	National Occupational Skills Standard
PEO	Programme Educational Objective
PS	Programme Standard
SDG	Sustainable Development Goals
SKM	*Sijil Kemahiran Malaysia*
SPM	*Sijil Pelajaran Malaysia*
STAM	*Sijil Tinggi Agama Malaysia*
STPM	*Sijil Tinggi Persekolahan Malaysia*
TVET	Technical and Vocational Education and Training
WBL	Work-based Learning

1. INTRODUCTION

One of the primary objectives of the Malaysian Qualifications Agency (MQA) is to monitor the quality of delivery, systems and processes used by Higher Education Providers (HEPs) to achieve learning outcomes. The prepared outlines have processes to ensure the quality of education and fair and ethical practices for learners to achieve the skills they need from the HEPs. This objective will provide qualifications that are relevant and valuable for the quality assurance areas of the students' intended disciplines and practices in the disciplinary areas of Computing.

Computing, for the purposes of this Programme Standard (PS), involves the study of computers and their applications. Thus, Computing includes designing and building hardware and software systems for a wide range of purposes such as processing, structuring, analysing, securing and managing various kinds of information including carrying out scientific studies using computers, making computer systems behave intelligently, integrating emerging technologies, creating findings and gathering information relevant to any particular purpose.

This PS measures the performance of other impacts and aspects of education, such as decentralisation, providing HEPs in various areas of autonomy and greater accountability for outcomes, which are equally important functions. Even though PS structures form a part of the higher education system within this tract, this given guidance is intended to formulate excellent programmes. Most of the areas measure performance; however, their precision, effectiveness and efficiency are dependent upon the HEP's manner of governance. The availability of a framework, political will, capacity of concerned personnel, accessibility and reliability of evidence, etc., are other critical issues that influence the level of impact and sustainability.

This PS prescribes a set of minimum criteria to ensure consistency in the quality of programmes offered by various HEPs, while also encouraging diversity and innovation. This will allow HEPs to craft their niches to meet the dynamics of the targeted employment markets and to meet the needs of society, in addition to the ethical responsibilities of the HEPs and students to engage in the direction toward the Sustainable Development Goals (SDG).

The involvement of all stakeholders in the making of this PS has greatly enhanced its ownership. The HEPs, as in the other sectors of development, have gone through stages of evolution over the years, starting from broad input-output monitoring to project-based

monitoring systems to meet the needs of the stakeholders, and onto the current discourse with a focus on providing timely and reliable data on evidence-based indicators of progress at the different levels of implementation, including at the industry and community levels. The ultimate aim of this PS initiative is to help HEPs develop and implement their programmes, which would not only help to systematically monitor and evaluate the key issues of the education sector but would also be timely, reliable and tailored to meet their needs of improving the quality, relevance and coverage of their education sectors.

The minimum criteria in the PS are based on what Is considered the minimum level that should be attained by HEPs to ensure that a programme can be adequately delivered. This, however, does not imply that HEPs should ultimately aim to merely satisfy these minimum criteria. Instead, they should strive for continual quality improvement.

For the Malaysian higher education sector of Computing, the learning framework is based on the Association for Computing Machinery (ACM) Problem Space of Computing at the bachelor's level. Computing is broadly categorised into five (5) major disciplines, namely Computer Science, Software Engineering, Information Technology, Information Systems and Data Science:

i. **Computer Science**: Graduates of this discipline should be prepared to work in a broad range of positions, involving tasks from theoretical work to software development, and could adapt to innovations in information and communication technology (ICT). Essentially, they are able to design and implement software; devise new ways to use computers; develop effective ways to solve computing problems; and plan and manage organisational technology infrastructure.
ii. **Software Engineering:** Graduates of this discipline should be able to perform and manage activities at every stage of the life cycle of large-scale software systems. They become specialists in designing and implementing software at large.
iii. **Information Technology**: Graduates of this discipline should be able to work effectively at planning, implementing, configuring and maintaining an organisation's computing infrastructure. They are to be prepared to succeed in roles involving planning and managing technology infrastructure.
iv. **Information Systems**: Graduates of this discipline should be able to analyse information requirements and business processes and be able to specify and design systems that are aligned with organisational goals.

v. **Data Science**: Graduates of this discipline should be able to use scientific methods to extract, process and analyse data; produce and visualise meaningful information; and perform programming related to data science fields.

The five (5) disciplines provide the basic platform for the placement of computing programmes. It is worth clarifying that **Computer Science and Software Engineering programmes prepare students for computing technology creation**; **Information Technology and Information Systems programmes are designed more towards producing experts in using technologies**; and **Data Science prepares students to be Data Scientists**. Other disciplines such as Computer Engineering and Creative Multimedia programmes are not covered by this PS since they fall under different fields. On the other hand, **Cybersecurity is a multidisciplinary field that can only be offered as a specialisation for any computing discipline according to the programme's aims**. Potential employers of new Computing Certificate, Diploma and Bachelor's degree graduates must be clear that each of the five (5) disciplines is different.

The detailed descriptions of the five (5) disciplines are as follows:

Computer Science spans a wide range, from its theoretical and algorithmic foundations to cutting-edge developments in Robotics, Computer Vision, Artificial Intelligence, Cloud Computing, the Internet of Things, Bioinformatics, Cybersecurity and other exciting areas. It involves designing and implementing software, devising new ways to use computers and developing effective ways to solve computing problems.

Computer Science offers a comprehensive foundation that permits graduates to adapt to new technologies and ideas. Computer scientists extend theories and practices for implementing computer systems, which have grown to include aspects of web development, interface design, security issues, edge computing, cloud computing and involvement in devising new ways to use computers. Computer scientists are expected to be flexible in performing all types of computer tasks, including software development, system administration, information analysis and others.

Software Engineering is the discipline of developing and maintaining software systems that behave reliably and efficiently, are affordable to develop and maintain, as well as built to customers' specifications. It has evolved in response to factors such as the growing impact of

large-scale software systems in various situations and the increased importance of software in safety-critical applications.

Software Engineering programmes produce graduates who can understand user requirements and develop software systems. Software Engineers are expected to develop systematic models and reliable techniques for producing high-quality software on time and within a budget.

Information Technology in the broadest sense refers to all aspects of computing. However, in academia, it often refers to meeting the technological needs of businesses, government, healthcare, schools and other kinds of organisations through the selection, creation, application, integration and administration of computing technologies.

Information Technology graduates are trained to focus on the application, deployment and configuration needs of organisations and people over a wide spectrum. Information Technology Professionals have a special focus on satisfying organisational needs that arise from Computing Technology. They assume responsibility for selecting hardware and software appropriate for an organisation, integrating these with organisational needs and its infrastructure, and installing, customising and maintaining those applications for the computer users in the organisation.

Information Systems integrates Information Technology solutions and business processes to meet the information needs of businesses and other enterprises, enabling them to achieve their objectives in effective and efficient ways. This discipline's perspective on Information Technology emphasises Information and views technology as an instrument for generating, processing and distributing information.

Information Systems programmes prepare graduates to work with business support applications, such as payroll, accounts, receivables and inventory management. Information Systems Specialists are expected to become familiar with computer applications related to these traditional business areas, especially database management systems and spreadsheets and other off-the-shelf software products.

Data Science concerns the confluence of the availability of data. Its increasing tools, processes and algorithms for analysing and drawing knowledge and insight from data have impacted every area of scientific engagement. It has also opened up exciting new

opportunities for interdisciplinary work across many fields, including (but certainly not limited to) computer science, mathematics, statistics and information science from which it draws foundational knowledge.

Data Science graduates acquire basic knowledge in computing and a strong foundation in mathematics and statistics. They are able to code using relevant programming languages and common libraries when needed; use scientific methods to extract, process and analyse data; and produce and visualise meaningful information.

As a whole, this PS describes the different levels of standards leading to the award of individual qualifications, namely Certificate [Level 3, Malaysian Qualifications Framework (MQF)], Diploma (Level 4, MQF), Bachelor's degree (Level 6, MQF), Master's degree (Level 7, MQF) and Doctoral degree (Level 8, MQF). This PS is designed to encourage a diversity of approaches within a framework compatible with national and global human resource requirements and socioeconomic needs. HEPs are expected to combine, teach and assess the subject matter creatively. This PS provides an inventory of content, delivery and assessment of programmes, thus enabling the identification of vital components of qualifications from certificate to doctoral awards.

The development and implementation of this PS are to ensure that graduates meet the professional requirements and expectations in their respective fields. HEPs must take into consideration the balance between the fundamental body of knowledge and the rapidly evolving subject matter and introduce effective and sustainable programme improvement. In doing so, the providers should also ensure that graduates obtain the necessary skills to function effectively.

Since 2010, MQA's PS: Computing has been a reference for HEPs in developing and offering Computing programmes. This review process is to ensure that the document is updated with current policies and the development of computing transformations. Assessors and Auditors are guided by those standards in arriving at their recommendations and conclusions.

It is important to note that all partnership or professional bodies or collaborative programmes should also comply with the requirement of this PS.

This PS covers all the seven quality assurance areas: (i) programme development and delivery, (ii) assessment of student learning, (iii) student selection and support services, (iv)

academic staff, (v) educational resources, (vi) programme management, and (vii) programme monitoring, review and continual quality improvement. This document describes the different levels of standards leading to the award of individual qualifications prescribed in the MQF based on different modes of study, which are:

1. Certificate (Level 3, MQF)
2. Diploma (Level 4, MQF)
3. Bachelor's Degree (Level 6, MQF)
4. Master's Degree (Level 7, MQF: Coursework, Mixed Mode and Research)
5. Doctoral Degree (Level 8, MQF: Mixed Mode and Research)

As the purpose of this PS is to provide minimum requirements pertaining to the development and conduct of different levels of Computing programmes within the core areas described, it is paramount that this document is read together with other quality assurance documents and policies issued by MQA, Professional Bodies and other related agencies, which include but are not limited to the following:

1. The Malaysian Qualifications Framework (MQF) 2nd Edition
2. The Code of Practice for Institutional Audit (COPIA)
3. The Code of Practice for TVET Programme Accreditation (COPTPA) 2nd Edition
4. The Code of Practice for Programme Accreditation (COPPA) 2nd Edition
5. The Code of Practice for Programme Accreditation: Open and Distance Learning (COPPA: ODL) 2nd Edition
6. Relevant Standards
7. Relevant Guidelines to Good Practices (GGP)

2. PROGRAMME DEVELOPMENT AND DELIVERY

2.1 PROGRAMME EDUCATIONAL OBJECTIVES

Programme Educational Objectives (PEOs) are broad statements that describe the career and professional accomplishments that the programme is preparing students to achieve after they graduate.

"The quality of a programme is ultimately assessed by the ability of its graduates to carry out their expected roles and responsibilities in society. This requires the programme to have a clear statement of the competencies, which are the practical, intellectual and soft skills expected to be achieved by the students at the end of the programme"' (COPPA 2nd Edition, 2017)

As indicated in the Introduction, Computing programmes can be broadly classified into five (5) main disciplines as defined by the ACM Curricular 2020: Computer Science, Software Engineering, Information Technology, Information Systems and Data Science. This classification has a bearing upon specific PEOs in the curriculum design for a high-quality learning environment that maximises the opportunity for all students to succeed and provides them with an inclusive, intellectually challenging and transformative educational experience.

Guidance of PEOs is provided under each level of study from the certificate to the doctoral levels. **The flexibility in describing the PEOs remains with the HEPs, provided that the PEOs are consistent with the vision and mission of the HEP.** It should be noted that the PEOs provided describe the minimum requirement, and HEPs may provide additional objectives where appropriate.

The PEOs of each level of qualification are outlined in Table 2.1.

Table 2.1

	Certificate (Essential)	**Diploma (Basic)**	**Bachelor's Degree (Proficient)**	**Master's Degree (Advanced)**	**Doctoral Degree (Expert)**
PEO1	Computer technicians have essential knowledge with appropriate technical and numeracy skills to solve simple problems in computing.	Computer technicians have basic knowledge with numeracy and technical skill to solve well-defined and routine problems in computing in line	Computing practitioners who are able to provide computing solutions for non-routine problems based on appropriate knowledge and	Computing specialists have advanced knowledge, applying enhanced technical and numeracy skills and focusing on the specific	Computing experts who are competent with a firm grounding in computing fields to foster research and development of new knowledge in the field of study.

	Certificate (Essential)	Diploma (Basic)	Bachelor's Degree (Proficient)	Master's Degree (Advanced)	Doctoral Degree (Expert)
		with the industry requirements.	technical skills in the discipline according to the industry requirements.	domains in the field of study to provide innovative solutions in computing.	
PEO2	Computer technicians have the supervisory ability and good interpersonal and communication skills to interact in a work environment.	Computer technicians have the supervisory ability and good interpersonal and communication skills to interact in various environments.	Computing practitioners have leadership skills and good interpersonal and communication skills to interact with stakeholders.	Computing specialists have leadership skills and good interpersonal and communication skills to interact with stakeholders effectively.	Computing experts who lead in their areas of expertise and are able to communicate convincingly and interact effectively with stakeholders.
PEO3	Computer technicians have a commitment to lifelong learning and an entrepreneurial mindset for self and career development.	Computer technicians have a commitment to lifelong learning and an entrepreneurial mindset for self and career development.	Computing practitioners who engage in lifelong learning and have an entrepreneurial mindset for self and career development.	Computing specialists who engage and advocate lifelong learning activities and have an entrepreneurial mindset.	Computing experts who engage and advocate lifelong learning activities and have an entrepreneurial mindset.
PEO4	Computer technicians who are committed to ethical conduct and professional practices in the organisation and society.	Computer technicians who are committed to ethical conduct and professional practices in the organisation and society.	Computing practitioners who uphold ethical conduct and professional practices in maintaining integrity.	Computing specialists who uphold and defend ethical conduct, professional practices and issues in maintaining integrity.	Computing experts who uphold and defend ethical conduct, professional practices and issues in advancing the profession while maintaining integrity.

2.2 PROGRAMME LEARNING OUTCOMES

Learning Outcomes (LO) or Programme Learning Outcomes (PLO) are detailed statements describing the learners' achievement in explicit terms, and they are achievable and assessable upon the completion of a period of study.

"A programme is designed and delivered to facilitate the attainment of a set of desired learning outcomes. It starts with a clear definition of the intended outcomes that students are to achieve by the end of the programme and supported by appropriate instructional approaches and assessment mechanisms." (COPPA 2nd Edition, 2017)

The learning outcomes in the field of Computing should **cumulatively reflect the five (5) clusters[1] of learning outcomes** aimed to develop well-balanced individuals with a holistic set of competencies.

The five (5) clusters of learning outcomes are:

1. Knowledge and understanding
2. Cognitive skills
3. Functional work skills, with focuses on:
    a. Practical skills
    b. Interpersonal skills
    c. Communication skills
    d. Digital skills
    e. Numeracy skills
    f. Leadership, autonomy and responsibility
4. Personal and entrepreneurial skills
5. Ethics and professionalism

Table 2.2 shows the mapping of learning outcomes based on the MQF learning outcomes for Computing. **The flexibility in describing the learning outcomes remains with the HEPs, provided they are sufficiently covered.**

[1] Malaysian Qualifications Agency (2017). Malaysian Qualifications Framework 2nd Edition. Cyberjaya, Malaysia.

Table 2.2: Programme Learning Outcomes (PLO) based on MQF 2.0's Learning Outcomes (LO) for Computing

CERTIFICATE (LEVEL 3, MQF)
At the end of the programme, graduates will be able to:

INFORMATION TECHNOLOGY

PLO	MQF 2.0										
	1	2	3	4	5	6	7	8	9	10	11
Explain essential knowledge of Information Technology related to job functions.	X										
Use Information Technology design and architecture to solve simple problems as described in user and technical manuals.		X									
Perform a range of support tasks on Information Technology related to job functions.			X								

INFORMATION SYSTEM

PLO	MQF 2.0										
	1	2	3	4	5	6	7	8	9	10	11
Explain essential knowledge of Information System related to job functions.	X										
Use Information System methods and tools to solve simple problems as described in user and technical manuals.		X									

Perform a range of support tasks on Information System related to job functions.			X								

COMPUTER SCIENCE

PLO	MQF 2.0										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Explain essential knowledge of Computer Science related to job functions.	X										
Use computing tools and techniques to solve simple problems as described in user and technical manuals.		X									
Perform a range of support tasks on computing related to job functions.			X								

SOFTWARE ENGINEERING

PLO	MQF 2.0										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Explain essential knowledge of Software Engineering related to job functions.	X										
Use a methodology and techniques to solve simple problems as described in user and technical manuals.		X									
Perform a range of support tasks on Software Engineering related to job functions.			X								

GENERIC LEARNING OUTCOMES FOR CERTIFICATE

PLO	MQF 2.0										
	1	2	3	4	5	6	7	8	9	10	11
Demonstrate effective interaction with stakeholders and society in a work-related environment.				X							
Exhibit effective communication with stakeholders and society in a work-related environment.					X						
Use relevant digital tools on computing related to job functions.						X					
Apply relevant numerical skills in computing related to job functions.							X				
Demonstrate supervisory skills and responsibility in executing instructions related to job functions.								X			
Apply skills and principles of lifelong learning in academic and career development.									X		
Demonstrate an entrepreneurial mindset in performing tasks.										X	
Commit to professional and ethical practices in executing instructions related to job functions.											X

1-Knowledge and Understanding; 2-Cognitive Skills; 3-Practical Skills; 4-Interpersonal Skills; 5-Communication Skills; 6-Digital Skills; 7-Numeracy Skills; 8-Leadership, Autonomy and Responsibility; 9-Personal Skills; 10-Entrepreneurial Skills; 11-Ethics and Professionalism.

DIPLOMA (LEVEL 4, MQF)
At the end of the programme, graduates will be able to:

INFORMATION TECHNOLOGY

PLO	MQF 2.0										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Explain concepts, principles and theories relating to Information Technology.	X										
Apply design and architecture to Information Technology solutions using appropriate tools and techniques.		X									
Perform support and development tasks on Information Technology solutions related to job functions.			X								

INFORMATION SYSTEM

PLO	MQF 2.0										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Explain concepts, principles and theories relating to Information System.	X										
Apply tools and techniques to Information System solutions.		X									
Perform support and development tasks on Information System solutions related to job functions.			X								

COMPUTER SCIENCE

PLO	MQF 2.0										
	1	2	3	4	5	6	7	8	9	10	11
Explain concepts, principles and theories relating to Computer Science.	X										
Apply computing tools and techniques to solve well-defined and routine problems and develop solutions.		X									
Perform a range of support and development tasks on computing related to job functions.			X								

SOFTWARE ENGINEERING

PLO	MQF 2.0										
	1	2	3	4	5	6	7	8	9	10	11
Explain concepts, principles and theories relating to Software Engineering.	X										
Apply a methodology and technique to solve well-defined and routine problems in software development.		X									
Perform a range of support and development tasks on software development job functions.			X								

GENERIC LEARNING OUTCOMES FOR DIPLOMA

PLO	MQF 2.0										
	1	2	3	4	5	6	7	8	9	10	11
Demonstrate effective interaction with stakeholders and society in a work-related environment.				X							
Exhibit effective communication with stakeholders and society in a work-related environment.					X						
Use appropriate digital tools on computing related to job functions.						X					
Apply appropriate numerical skills in computing related to job functions.							X				
Demonstrate supervisory skills and responsibility in executing instructions related to job functions.								X			
Commit to principles of lifelong learning in academic and career development.									X		
Demonstrate an entrepreneurial mindset in performing tasks.										X	
Commit to professional and ethical practices in executing instructions related to the job and organisational functions.											X

1-Knowledge and Understanding; 2-Cognitive Skills; 3-Practical Skills; 4-Interpersonal Skills; 5-Communication Skills; 6-Digital Skills; 7-Numeracy Skills; 8-Leadership, Autonomy and Responsibility; 9-Personal Skills; 10-Entrepreneurial Skills; 11-Ethics and Professionalism.

BACHELOR'S DEGREE (LEVEL 6, MQF)
At the end of the programme, graduates will be able to:

INFORMATION TECHNOLOGY

PLO	MQF 2.0										
	1	2	3	4	5	6	7	8	9	10	11
Analyse concepts, principles and theories relating to Information Technology.	X										
Apply appropriate design and architecture for Information Technology solutions.		X									
Build Information Technology solutions for non-routine problems.			X								

INFORMATION SYSTEM

PLO	MQF 2.0										
	1	2	3	4	5	6	7	8	9	10	11
Analyse concepts, principles and theories relating to Information System.	X										
Apply appropriate principles of Information System in providing enterprise solutions.		X									
Construct Information System solutions for enterprise non-routine problems.			X								

COMPUTER SCIENCE

PLO	MQF 2.0										
	1	2	3	4	5	6	7	8	9	10	11
Analyse concepts, principles and theories relating to Computer Science.	X										
Apply appropriate algorithms and techniques for computing solutions.		X									
Construct computing solutions using appropriate algorithms and techniques for non-routine problems.			X								

SOFTWARE ENGINEERING

PLO	MQF 2.0										
	1	2	3	4	5	6	7	8	9	10	11
Analyse facts, concepts, principles and theories relating to Software Engineering.	X										
Apply appropriate methodologies and techniques for software development.		X									
Construct software engineering solutions using appropriate methodologies and techniques for non-routine problems.			X								

DATA SCIENCE

PLO	MQF 2.0										
	1	2	3	4	5	6	7	8	9	10	11
Analyse data, concepts, principles and theories relating to Data Science.	X										
Apply appropriate concepts and methods for optimised Data Science solutions.		X									
Build Data Science solutions using appropriate concepts and methods for non-routine problems.			X								

GENERIC LEARNING OUTCOMES FOR BACHELOR'S DEGREE

PLO	MQF 2.0										
	1	2	3	4	5	6	7	8	9	10	11
Demonstrate effective interaction with diverse stakeholders.				X							
Exhibit effective communication with diverse stakeholders.					X						
Utilise digital skills for problem-solving in the field of study.						X					
Apply numeracy skills for problem-solving in the field of study.							X				
Demonstrate teamwork, accountability, autonomy and responsibility in delivering solutions related to the field of study.								X			
Exhibit capabilities to extend relevant knowledge through life-long learning.									X		
Apply an entrepreneurial mindset in delivering solutions.										X	
Uphold professional and ethical practices in the work environment.											X

MASTER'S DEGREE (LEVEL 7, MQF)

At the end of the programme, graduates will be able to:

PLO	MQF 2.0										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Integrate advanced knowledge related to research issues in computing.	X										
Recommend innovative solutions that are at the forefront of developments in the fields of study.		X									
Construct computing solutions and tools in terms of their usability, efficiency and effectiveness.			X								
Demonstrate effective interaction within a group and with a diverse audience through project discussions and participation in discourses related to the field of study.				X							
Exhibit effective communication within a group and with a diverse audience by publishing and presenting technical materials in the field of study.					X						
Utilise digital skills to acquire, interpret and extend knowledge in computing.						X					
Apply numerical skills to acquire, interpret and extend knowledge in computing.							X				
Demonstrate leadership, teamwork, autonomy and responsibility in delivering services related to the field of study.								X			
Exhibit capabilities to extend relevant knowledge through life-long learning.									X		
Exhibit capabilities of having an entrepreneurial mindset to the related field of study.										X	
Uphold professional and ethical practices in conducting research and delivering services related to the field of study.											X

1-Knowledge and Understanding; 2-Cognitive Skills; 3-Practical Skills; 4-Interpersonal Skills; 5-Communication Skills; 6-Digital Skills; 7-Numeracy Skills; 8-Leadership, Autonomy and Responsibility; 9-Personal Skills; 10-Entrepreneurial Skills; 11-Ethics and Professionalism.

DOCTORAL DEGREE (LEVEL 8, MQF)
At the end of the programme, graduates will be able to:

PLO	MQF 2.0										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Integrate state-of-art knowledge through a systematic comprehension and in-depth understanding of the field of study.	X										
Develop original research work that broadens the boundary of knowledge through an in-depth thesis that has been presented and defended according to HEP standards.		X									
Develop innovative computing solutions that stand the tests of applicability, efficiency and effectiveness.			X								
Demonstrate effective interaction with peers, scholarly communities and society of diverse audiences through participation in discourses related to the field of study.				X							
Exhibit effective communication with peers, scholarly communities and society of diverse audiences by publishing and presenting technical materials in the fields of study.					X						
Utilise appropriate digital tools to acquire, interpret and extend knowledge in computing.						X					
Apply appropriate numerical techniques to acquire, interpret and extend knowledge in computing.							X				
Demonstrate leadership, teamwork, autonomy and responsibility in conducting research based on computing theoretical framework.								X			
Exhibit capabilities to extend relevant knowledge through life-long learning.									X		
Exhibit capabilities of having an entrepreneurial mindset related to the field of study.										X	

Uphold professional and ethical practices in conducting research and delivering solutions related to the field of study.											X

1-Knowledge and Understanding; 2-Cognitive Skills; 3-Practical Skills; 4-Interpersonal Skills; 5-Communication Skills; 6-Digital Skills; 7-Numeracy Skills; 8-Leadership, Autonomy and Responsibility; 9-Personal Skills; 10-Entrepreneurial Skills; 11-Ethics and Professionalism.

2.3 CURRICULUM DESIGN AND DELIVERY[2]

Learning and teaching can only be effective when the curriculum content and the programme structure are kept abreast with the most current development in the field of study (COPPA 2nd Edition, 2017). The curriculum structure should identify the objectives and learning outcomes of the programme and incorporate a schema that would map the curriculum to the stated objectives and learning outcomes (Guidelines to Good Practice: Curriculum Design and Delivery, 2011).

This section outlines the minimum credits of each curriculum component for all levels of qualifications as stated in **Table 2.3**. Specific requirements of the body of knowledge of the various core areas are in **Appendix 3**. **HEPs have the flexibility to design their programmes. However, they should cover the body of knowledge indicated in this PS.**

In addition, HEPs are encouraged to develop their programmes to reflect the current best practices and offer a high-quality academic programme. Computing programmes may vary in their nomenclature; however, the programme nomenclature must reflect the content of the programme as indicated in the MQF. Examples of knowledge areas for each level are in **Appendix 4**.

Table 2.3: Minimum credits of each curriculum component for all levels of qualifications

CERTIFICATE (LEVEL 3, MQF)

COMPONENT	MINIMUM CREDIT
Compulsory Courses (General* and HEP courses)	4
Core Computing Courses	24
Discipline Core of Knowledge Area Courses**	18
Industrial Training***	4
Free Electives**** (optional)	0
Project	0
Subtotal Credits	**50**
To complete the minimum requirement of 60 credits, the remaining 10 credits can be placed in any of the categories above.	
GRADUATING CREDITS	**60**

[2] Standards in this area are best read together with the Guidelines to Good Practices: Curriculum Design and Delivery, which is available on the MQA Portal: www.mqa.gov.my.

CORE COMPUTING COURSES

1. Computer Architecture
2. Database Fundamentals
3. Basic Mathematics
4. Network and Data Communication
5. Operating Systems
6. Programming Fundamentals
7. Cybersecurity Fundamentals
8. System Analysis and Design Fundamentals

Notes:

*****	General courses refer to *Mata Pelajaran Pengajian Umum (MPU)* courses, which are mandatory. Please refer to *Garis Panduan Mata Pelajaran Pengajian Umum (MPU) Edisi Kedua* for the minimum credit requirement as stipulated by the Ministry of Higher Education (MOHE). The HEP has the option to offer its own compulsory courses in addition to the general courses.
******	The Discipline Core of Knowledge Area represents the core knowledge area for a specific area of computing, except for Data Science.
*******	● Industrial training must be in a relevant industry and is allocated at a minimum number according to the formula of 1 credit = 2 weeks of training. It is recommended to be placed in the final year. ● The minimum recommendation is 4 credits (2 months).
********	● Free electives represent the non-computing courses. ● Flexibility is given to the HEP to determine the appropriate range.

Recommended Delivery Methods:

- Lecture / Tutorial
- Practical class / Practical workshop / Studio / Laboratory work / Demonstration technique
- Work-based learning (WBL) (conventional, 2 years in university and 2 years in industry [2u2i], incubation, technopreneurship)
- Blended learning
- Industry speaker
- Field / Industry visit
- Apprenticeship
- Industrial training

DIPLOMA (LEVEL 4, MQF)

COMPONENT	MINIMUM CREDIT
Compulsory Courses (General* and HEP courses)	6
Core Computing Courses	33
Discipline Core of Knowledge Area Courses**	24
Industrial Training***	6
Free Electives**** (optional)	0
Project	4
Subtotal Credits	**73**
To complete the minimum requirement of 90 credits, the remaining 17 credits can be placed in any of the categories above.	
GRADUATING CREDITS	**90**

CORE COMPUTING COURSES

1. Computer Architecture
2. Database Fundamental
3. Discrete Mathematics
4. Calculus and Algebra
5. Network and Data Communication
6. Operating Systems
7. Programming Fundamentals
8. System Analysis and Design Fundamentals
9. Statistics and Probability
10. Cybersecurity Fundamentals
11. Ethics in Computing

Notes:

*****	General courses refer to *Mata Pelajaran Pengajian Umum (MPU)* courses, which are mandatory. Please refer to *Garis Panduan Mata Pelajaran Pengajian Umum (MPU) Edisi Kedua* for the minimum credit requirement as stipulated by the Ministry of Higher Education (MOHE). The HEP has the option to offer its own compulsory courses in addition to the General courses.
******	The Discipline Core of Knowledge Area represents the core knowledge area for a specific area of computing, except for Data Science.
***	● Industrial training must be in a relevant industry and is allocated at a minimum number according to the formula of 1 credit = 2 weeks of training. It is recommended to be placed in the final year. ● The minimum recommendation is 6 credits (3 months).
****	● Free electives represent the non-computing courses. ● Flexibility is given to the HEP to determine the appropriate range.

Recommended Delivery Methods:

- Lecture / Tutorial
- Practical class / Practical workshop / Studio / Laboratory work / Demonstration technique
- WBL (conventional, 2u2i, incubation, technopreneurship)
- Blended learning
- Industry speaker
- Field / Industry visit
- Apprenticeship
- Industrial training
- Exhibition

BACHELOR'S DEGREE (LEVEL 6, MQF)

<table>
<tr><th rowspan="2"></th><th rowspan="2">Single Major</th><th rowspan="2">Major with Specialisation</th><th rowspan="2">Major-Minor</th><th colspan="2">Double Major (In Computing Discipline)</th><th colspan="2">Double Major (In Non-Computing Discipline)</th></tr>
<tr><th>Major 1</th><th>Major 2</th><th>Major 1</th><th>Major 2</th></tr>
<tr><td>Compulsory Courses (General* & HEP courses)</td><td colspan="7">8</td></tr>
<tr><td>Core Computing Courses</td><td colspan="7">18</td></tr>
<tr><td>Discipline Core of Knowledge Area Courses</td><td colspan="3">33</td><td>33</td><td>33</td><td>33</td><td rowspan="2">51 (Second major must comply with the specific PS)</td></tr>
<tr><td>Field Electives</td><td>18</td><td>-</td><td>12</td><td colspan="2">18</td><td>18</td></tr>
<tr><td>Specialisation</td><td>-</td><td>18</td><td colspan="4">-</td><td>-</td></tr>
<tr><td>Minor</td><td colspan="2">-</td><td>30</td><td colspan="3">-</td><td>-</td></tr>
<tr><td>Industrial Training**</td><td colspan="7">6</td></tr>
<tr><td>Final Year Project</td><td colspan="7">6</td></tr>
<tr><td>Free Module (Non-Computing)***</td><td colspan="2">12</td><td>-</td><td colspan="2">12</td><td>-</td><td>-</td></tr>
<tr><td>Subtotal Credits</td><td colspan="2">101</td><td>113</td><td colspan="2">134</td><td>-</td><td>-</td></tr>
<tr><td>Remaining Credits</td><td colspan="2">19</td><td>7</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Graduating Credits</td><td colspan="3">120</td><td colspan="2">134</td><td colspan="2">140</td></tr>
</table>

CORE COMPUTING COURSES

1. Computer Architecture
2. Database Fundamentals
3. Network and Data Communication
4. Operating Systems
5. Programming Fundamentals
6. System Analysis and Design Fundamentals

Single Major Programme

COMPONENT	MINIMUM CREDIT
Compulsory Courses (General* and HEP courses)	8
Core Computing Courses	18
Discipline Core of Knowledge Area Courses	33
Field Electives	18
Industrial Training**	6
Free Electives***	12
Final Year Project	6
Subtotal Credits	**101**
To complete the minimum requirement of 120 credits, the remaining 19 credits can be placed in any of the categories above.	
GRADUATING CREDITS	**120**

Major with Specialisation Programme

COMPONENT	MINIMUM CREDIT
Compulsory Courses (General* and HEP courses)	8
Core Computing Courses	18
Discipline Core of Knowledge Area Courses	33
Specialisation	18
Industrial Training**	6
Free Electives***	12
Final Year Project	6
Subtotal Credits	**101**
To complete the minimum requirement of 120 credits, the remaining 19 credits can be placed in any of the categories above.	
GRADUATING CREDITS	**120**

Major- Minor Programme

COMPONENT	MINIMUM CREDIT
Compulsory Courses (General* and HEP courses)	8
Core Computing Courses	18
Discipline Core of Knowledge Area Courses	33
Field Electives	12
Minor	30
Industrial Training**	6
Final Year Project	6
Subtotal Credits	**113**
To complete the minimum requirement of 120 credits, the remaining 7 credits can be placed in any of the categories above.	
GRADUATING CREDITS	**120**

Double Major Programme

Double Major in Computing Discipline

COMPONENT	MINIMUM CREDIT
Compulsory Courses (General* and HEP courses)	8
Core Computing Courses	18
Discipline Core (Major 1)	33
Discipline Core (Major 2)	33
Field Electives	18
Industrial Training**	6
Free Electives***	12
Final Year Project	6
GRADUATING CREDITS	**134**

Double Major in Non-Computing Discipline

COMPONENT	MINIMUM CREDIT
Compulsory Courses (General* and HEP courses)	8
Core Computing Courses	18
Discipline Core of Knowledge Area	33
Field Electives	18

Final Year Project	6
The core of Second Major from other disciplines****	51 (Second major must comply with the specific PS)
Industrial Training**	6 (Second major must comply with the specific PS)
Free Electives***	0
GRADUATING CREDITS	**140**

Notes:

*	General courses refer to *Mata Pelajaran Pengajian Umum (MPU)* courses, which are mandatory. Please refer to *Garis Panduan Mata Pelajaran Pengajian Umum (MPU) Edisi Kedua* for the minimum credit requirement as stipulated by the Ministry of Higher Education (MOHE). The HEP has the option to offer its own compulsory courses in addition to the general courses.
**	● Industrial training must be in a relevant industry and is allocated at a minimum according to the formula of 1 credit = 2 weeks of training. It is recommended to be placed in the final year. ● At a Bachelor's degree level, **Industrial Training is COMPULSORY** with a minimum of 6 credits (3 months). ● **Final Year Project and Industrial Training must reflect both major disciplines.**
***	● Free electives represent the non-computing courses. ● Flexibility is given to the HEP to determine the appropriate range.
****	For a double major programme, if the majors are governed by PSs, the minimum core requirements can be based on the respective PS. However, the minimum graduating credit specified in this PS must be fulfilled.

Recommended Delivery Methods:

- Lecture / Tutorial
- Interactive learning
- Blended learning
- Practical class / Practical workshop / Studio / Laboratory work / Demonstration technique
- Field / Industry visit
- Fieldwork
- Apprenticeship
- Industrial training
- Industry speaker
- Task-based learning
- Problem-based learning

- Project-based learning
- WBL (conventional, 2u2i, incubation, technopreneurship)
- Experiential learning
- Final year project
- Seminar
- Empirical study
- Case study
- Exhibition

MASTER'S DEGREE by COURSEWORK (LEVEL 7, MQF)

COMPONENT	MINIMUM CREDIT
Core Modules (including research methodology)	18
Master Project Report	9
Electives	9
Subtotal Credits	**36**
To complete the minimum requirement of 40 credits, the remaining 4 credits can be placed in any of the categories above.	
GRADUATING CREDITS	**40**

Note:

Coursework components must include a Research Methodology. (Refer to the Standards Master's and Doctoral Degree).

Recommended Delivery Methods:

- Lecture
- Practical class / Practical workshop / Studio / Laboratory work / Demonstration technique
- Blended learning
- Studio work
- Fieldwork
- Apprenticeship
- Guest lecture series (prominent speakers from the industry and academic institutions)
- Seminar
- Exhibition
- Face-to-face supervision
- Workshop
- Case study

MASTER'S DEGREE by MIXED MODE (LEVEL 7, MQF)

COMPONENT	MINIMUM CREDIT
Core Modules (including research methodology)	12
Master's Dissertation	20
Subtotal Credits	**32**
To complete the minimum requirement of 40 credits, the remaining 8 credits can be placed according to the ratio of coursework to dissertation, which is 50:50, 40:60 or 30:70.	
GRADUATING CREDITS	**40**

Notes:

i. Coursework components must include a Research Methodology.

ii. The ratio of coursework to dissertation is 50:50 or 40:60 or 30:70. (Refer to the Standards Master's and Doctoral Degree).

iii. Students are required to undertake research in a related field of study and submit a dissertation.

iv. The recommended minimum number of words is 20,000.

Recommended Delivery Methods:

- Lecture
- Practical class / Practical workshop / Studio / Laboratory work / Demonstration technique
- Blended learning
- Studio work
- Fieldwork
- Apprenticeship
- Guest lecture series (prominent speakers from the industry and academic institutions)
- Seminar
- Exhibition
- Face-to-face supervision
- Workshop
- Case study

MASTER'S DEGREE by RESEARCH (LEVEL 7, MQF)

COMPONENT	MINIMUM CREDIT
Research Methodology	Compulsory
Master's Dissertation	100%
Related pre-requisites modules	Optional
Subtotal Credits	**-**
GRADUATING CREDITS	**-**

Notes:

i. Students are required to undertake research in a related field of study and submit a dissertation.

ii. The HEP must have a set of procedures and guidelines pertaining to:
   a) The minimum and maximum periods of study.
   b) Format of the dissertation (refer to the Standards Master's and Doctoral Degree)
   c) The recommended minimum number of words is 40,000.

Recommended delivery methods:

- Lecture
- Face-to-face supervision
- Seminar / Workshop
- Supervision of dissertation

DOCTORAL DEGREE by MIXED MODE / INDUSTRY (LEVEL 8, MQF)

COMPONENT	MINIMUM CREDIT
Core Modules (including research methodology)	24*
Doctoral Thesis	40
Subtotal Credits	**64**
To complete the minimum requirement of 80 credits, the remaining 16 credits can be placed according to the ratio of coursework to thesis, which is 50:50 or 40:60 or 30:70	
GRADUATING CREDITS	**80**

*The selection of core modules should consist of appropriate topics inside or outside the field of study (minimum at a degree level) subject to agreement from the supervising committee to help students prepare the doctoral thesis.

Notes:

i. The candidate should achieve a grade point of at least 3.0 for each of the core modules to proceed with the thesis.
ii. Students are required to undertake research in a related field of study and submit a thesis.
iii. The ratio of coursework to dissertation is 50:50 or 40:60 or 30:70 (refer to the Standards: Master's and Doctoral Degree).
iv. The programme must include appropriate training in Research Methodology.
v. The HEP must have a set of procedures and guidelines pertaining to the format of the thesis (refer to the Standards Master's and Doctoral Degree) or the format of the dissertation.
vi. The recommended minimum number of words is 40,000.

Recommended delivery methods:

- Lecture
- Blended learning
- Practical class / Laboratory work
- Studio work practical class / Practical workshop / Studio / Laboratory work / Demonstration technique
- Fieldwork
- Apprenticeship
- Guest lecture series (prominent speakers from the industry and academic institutions)
- Seminar
- Exhibition
- Face-to-face supervision
- Workshop
- Case study

DOCTORAL DEGREE by RESEARCH / INDUSTRY (LEVEL 8, MQF)

COMPONENT	MINIMUM CREDIT
Research Methodology	Compulsory
Doctoral Thesis	100%
Related pre-requisites modules	Optional
Subtotal Credits	**-**
GRADUATING CREDITS	**-**

Notes:

i. Students are required to undertake research in a related field of study and submit a thesis.

ii. The HEP must have a set of procedures and guidelines pertaining to:
   a) The minimum and maximum periods of study.
   b) Format of the thesis (refer to the Standards Master's and Doctoral Degree).
   c) The recommended minimum number of words is 80,000.

DOCTORAL DEGREE by RETROSPECTIVE OR PRIOR PUBLICATION (LEVEL 8, MQF)

COMPONENT	MINIMUM CREDIT
Research Methodology	Compulsory
Doctoral Thesis (Prior Publication)	100%
Related pre-requisites modules	Optional
Subtotal Credits	**-**
GRADUATING CREDITS	**-**

Notes:

i. The applicant must have publications that contribute to the scholarship of knowledge in the field and are acknowledged by academic peers. A formal application must be submitted to the HEP and must include:
   a) A minimum of five (5) publications or equivalent works in alignment with the theme of the specialisation.
   b) An executive summary of the above publications to demonstrate the applicant's contribution to knowledge in the field.
   c) A list of scholarly / peer-reviewed publications or equivalent (refer to the Standards Master's and Doctoral Degree).

Recommended delivery methods:

- Lecture
- Face-to-face supervision
- Seminar / Workshop
- Training attachment

NOMENCLATURE IN COMPUTING

The nomenclature in Computing must be **prefixed by the five (5) disciplines** mentioned earlier to avoid confusion, except for **the Certificate and Diploma levels which do not offer the Data Science** discipline. **Any of the five (5) disciplines should not be a specialisation.** Consistent nomenclature will reduce the gap between the capabilities of fresh graduates and the expectations of employers. However, for the postgraduate programmes, HEPs may determine the specific nomenclature for their awards based on existing national and international best practices. For Computing as an **extension to different fields**, such as Business, Accounting, Biology and Arts, the nomenclature of Computing should, nevertheless, use the five (5) disciplines mentioned above. Further explanation of these nomenclatures and their examples are shown in **Appendix 5**. Any programme that does not comply with this PS should not use the naming conventions specified in this PS.

3. ASSESSMENT OF STUDENT LEARNING[3]

"Assessment of students learning is a key aspect of quality assurance, and it is one of the most important measures to show the achievement of learning outcomes. Hence, it is crucial for an appropriate assessment method and mechanism to be in place. Qualifications are awarded based on the results of the assessment. The methods of student assessment must be clear, consistent, effective, reliable and in line with current practices. They must clearly measure the achievement of the intended learning outcomes" (COPPA 2nd Edition, 2017).

The methods of assessment depend on the specific requirements of each course. Nonetheless, the following must be considered as a general guide:

i. Assessments should comprise continuous and final assessments.
ii. Final assessment should be individually assessed and must undergo a comprehensive vetting process. It must cover comprehensively the contents of the courses.
iii. Assessments must be appropriate to the learning outcomes.
iv. Candidates are required to pass **BOTH continuous and final assessments** for **every computing course**. HEPs can define the meaning of a pass based on their grading system for overall marks; however, a pass should imply that the examiner is satisfied that the candidate has met all the learning outcomes of a particular course.
v. The HEP must have clear marking guidelines, such as assessment rubrics and marking schemes, for continuous and final assessments to indicate the achievement of the course learning outcomes.
vi. Continuous Assessments for the WBL or 2u2i mode of study (industry components) can be either conducted solely by an industry coach or conducted jointly by an industry coach and HEP academic staff (refer to Guideline 2u2i and WBL).
vii. Final Assessments for the WBL or 2u2i mode of study (industry components) must be conducted jointly by an industry coach and HEP academic staff (refer to Guideline 2u2i and WBL).

[3] Standards in this area are best read together with the Guidelines to Good Practices: Assessment of Students, which is available on the MQA Portal: www.mqa.gov.my.

The types of assessments indicated below are **suggested ranges of percentages.** HEPs are encouraged to use a variety of methods and tools appropriate for measuring learning outcomes and competencies. The suggested forms of assessments for each level of study are presented in **Table 3.**

Table 3: Type of assessment for each level of study

LEVEL	CONTINUOUS ASSESSMENT (%)	FINAL ASSESSMENT (%)	SUGGESTED FORM OF ASSESSMENT
CERTIFICATE (LEVEL 3, MQF)	50 to 70	30 to 50	○ Assignment ○ Quiz / Test ○ Demonstration ○ Observation ○ Presentation ○ Practical assessment ○ Reflective module assessment ○ Self-reflective report ○ Peer assessment ○ Portfolio / Logbook ○ Final examination (written/oral) ○ Project ○ Simulation
DIPLOMA (LEVEL 4, MQF)	50 to 70	30 to 50	
BACHELOR'S DEGREE (LEVEL 6, MQF)	40 to 70	30 to 60	
MASTER'S DEGREE (LEVEL 7, MQF) **COURSEWORK**	40 to 60	40 to 60	○ Assignment ○ Course / Module project ○ Written / Oral assessment ○ Presentation ○ Seminar ○ Research / Capstone project ○ Project report ○ Exhibition ○ Review and critique ○ Graduate seminar

LEVEL	CONTINUOUS ASSESSMENT (%)	FINAL ASSESSMENT (%)	SUGGESTED FORM OF ASSESSMENT
MASTER'S DEGREE (LEVEL 7, MQF) **MIXED MODE**	30 to 40	60 to 70	○ Assignment ○ Course / Module project ○ Presentation ○ Written / Oral assessment ○ Seminar ○ Research / Capstone project ○ Dissertation ○ Review and critique ○ Graduate seminar ○ Simulation ○ Proposal defence ○ Research progress ○ Viva voce
MASTER'S DEGREE (LEVEL 7, MQF) **RESEARCH**	0	100 (Dissertation)	○ Proposal defence ○ Research progress ○ Dissertation ○ Viva voce ○ Presentation ○ Seminar ○ Simulation
DOCTORAL DEGREE (LEVEL 8, MQF) **MIXED MODE / INDUSTRY**	30 to 40	60 to 70	○ Assignment ○ Course / Module project ○ Presentation ○ Seminar ○ Written / Oral assessment ○ Viva voce ○ Thesis ○ Review and critique ○ Final project ○ Graduate seminar ○ Graduate exhibition (online / virtual / conventional) ○ Simulation
DOCTORAL DEGREE (LEVEL 8, MQF) **RESEARCH / BY PRIOR PUBLICATION / INDUSTRY**	0	100 (Thesis)	○ Proposal defence ○ Research progress ○ Thesis ○ Viva voce ○ Presentation ○ Seminar ○ Simulation ○ Publication

Notes:

i. The HEPs should have a clear policy on the appointment of External and Internal Examiners.

ii. The examiners should be from the related field of study.

iii. The composition of dissertation / thesis examiners is prescribed as follows:

   a. Master's degree by Coursework

      The master's project report is to be examined by at least two examiners (including the supervisor).

   b. Master's degree by Mixed Mode / Research

      The dissertation is to be examined by at least two examiners, one of whom is an external examiner (from an academic field or industry related to the candidate's field of discipline). More than two examiners may be necessary in the case of a multidisciplinary dissertation.

   c. Doctoral degree by Mixed Mode / Research / Prior Publication

      The thesis is to be examined by at least two examiners, one of whom is an External Examiner (from an academic field or industry related to the candidate's field of discipline). More than two examiners may be necessary in the case of a multidisciplinary dissertation.

iv. The assessment **for master's and doctoral programmes** for any specialisation in the computing areas **(without prefix)** should follow the following requirements:

   a. Must have a rubric to reflect the knowledge area of the defined discipline/s.

   b. The title of the research should reflect the defined discipline/s.

   c. The supervisors and examiners must be in the defined discipline/s.

4. STUDENT SELECTION

This section of the PS relates to the selection of students for programmes of study.

"In general, admission to a programme needs to comply with the prevailing policies of the Ministry of Higher Education (MOHE). There are varying views on the best method of student's selection. Whatever method is used, the HEP must be able to defend the consistency of the method it utilises. The number of students to be admitted to a programme is determined by the capacity of the HEP and the number of qualified applicants. HEP admission and retention policies must not be compromised for the sole purpose of maintaining the desired enrolment. If a HEP operates geographically separated campuses or if the programme is a collaborative one, the selection and assignment of all students must be consistent with national policies." (COPPA 2nd Edition, 2017)

The standards for the selection of students into Computing programmes are formulated by keeping in mind the generic national Higher Education policies pertaining to minimum student entry requirements.

The benchmarked standards are in **Table 4** as follows:

Table 4: General requirement for student admission

LEVEL	ENTRY REQUIREMENT	ENGLISH COMPETENCY REQUIREMENT (INTERNATIONAL STUDENT)
CERTIFICATE (LEVEL 3, MQF)	i. Possess *Sijil Pelajaran Malaysia* (SPM) or its equivalent with at least ONE (1) credit and a pass in Mathematics; **OR** ii. Possess *Sijil Kemahiran Malaysia* (SKM) Level 2 in a related field and a pass in Mathematics at SPM level or its equivalent; **OR** iii. Other relevant equivalent qualifications recognised by the Malaysian Government.	Achieve a minimum score of 4.0 in the International English Language Testing System (IELTS) or equivalent. If a student does not meet this requirement, the HEP must offer English proficiency courses to ensure that the student's proficiency is sufficient to meet the needs of the programme.

LEVEL	ENTRY REQUIREMENT	ENGLISH COMPETENCY REQUIREMENT (INTERNATIONAL STUDENT)
DIPLOMA (LEVEL 4, MQF)	i. Possess SPM with at least THREE (3) credits in any subjects (inclusive of Mathematics or any equivalent qualification); **OR** ii. A pass in *Sijil Tinggi Persekolahan Malaysia* (STPM) with a minimum grade of C [Cumulative Grade Point Average (CGPA) 2.00] in any subject or equivalent qualification and a credit in Mathematics at SPM level or its equivalent; **OR** iii. A pass in *Sijil Tinggi Agama Malaysia* (STAM) with a minimum grade of *Maqbul* (Pass) and a credit in Mathematics at SPM level or its equivalent; **OR** iv. Possess SKM Level 3 and a credit in Mathematics at SPM level or its equivalent; **OR** v. A Certificate (Level 3, MQF) in any qualification with at least a CGPA of 2.00; **OR** vi. A pass in any qualification equivalent to certificate (Level 3, MQF); **OR** vii. Other relevant & equivalent qualifications recognised by the Malaysian Government. **Notes:** ● Candidates with a pass in Mathematics at an SPM level or its equivalent may be admitted if the certificate programme contains subjects in Mathematics that are equivalent to Mathematics at SPM level. ● Candidates with a pass in Mathematics at SPM level and without a related certificate need to take a reinforcement Mathematics subject with appropriate topics in the discipline of Computing at the beginning of the study. ● Candidate with a credit in a Computing-related subject at SPM level or its equivalent may be given preferential consideration.	Achieve a minimum score of 4.0 in the IELTS or equivalent. If a student does not meet this requirement, the HEP must offer English proficiency courses to ensure that the student's proficiency is sufficient to meet the needs of the programme.

LEVEL	ENTRY REQUIREMENT	ENGLISH COMPETENCY REQUIREMENT (INTERNATIONAL STUDENT)
BACHELOR'S DEGREE (LEVEL 6, MQF)	**Bachelor's Degree in Information Technology / Information Systems** i. A pass in STPM with a minimum grade of C (CGPA 2.00) in any TWO (2) subjects or any equivalent qualification and a credit in Mathematics at SPM level or its equivalent; **OR** ii. A pass in STAM with a minimum grade of *Jayyid* in any TWO (2) subjects (including a credit in Mathematics at SPM level or its equivalent or its equivalent); **OR** iii. A pass in Matriculation or Foundation studies with a minimum CGPA of 2.00 and a credit in Mathematics at SPM level or its equivalent; **OR** iv. Diploma in Computing (Level 4, MQF) or equivalent with a minimum CGPA of 2.50; **OR** v. Any Diploma in Science and Technology (Level 4, MQF) with a minimum CGPA of 2.75; **OR** vi. *Diploma Kemahiran Malaysia (DKM) / Diploma Vokasional Malaysia (DVM)* in Computing fields with a minimum CGPA of 2.50 subjected to HEP Senate / Academic Board's approval; **OR** vii. *Diploma Lanjutan Kemahiran Malaysia (DLKM)* in Computing fields with a minimum CGPA of 2.50 subjected to HEP Senate / Academic Board's approval; **Note:** • Candidates for categories (iv) until (vii) with a CGPA below 2.75 but more than 2.00 may be admitted subject to a thorough internal evaluation process.	Achieve a minimum score of 5.0 in the IELTS or equivalent. If a student does not meet this requirement, the HEP must offer English proficiency courses to ensure that the student's proficiency is sufficient to meet the needs of the programme.

LEVEL	ENTRY REQUIREMENT	ENGLISH COMPETENCY REQUIREMENT (INTERNATIONAL STUDENT)
	Bachelor's Degree in Computer Science / Software Engineering / Data Science i. A pass in Matriculation or Foundation studies with a minimum CGPA of 2.00; **OR** ii. A pass in STPM with a minimum grade of C (CGPA 2.00) in any TWO (2) subjects or any equivalent qualification; **OR** iii. A pass in STAM with a minimum grade of *Jayyid* in any TWO (2) subjects; **OR** **AND** a credit in: a. Additional Mathematics at SPM level or its equivalent; **OR** b. Mathematics and any one of the Science, Technology or Engineering subjects at SPM level or its equivalent. **Notes:** ● Candidates for category (b) need to take a reinforcement Mathematics with appropriate topics in the discipline of Computer Science, Data Science or Software Engineering at the beginning of the study. ● Students are required to pass the reinforcement Mathematics as a prerequisite before being allowed to take related core courses. The candidate can sit for any subjects that did not indicate Mathematics as a pre-requisite. ● Reinforcement Mathematics can contribute to the overall graduating credit. ● Students from Matriculation / Foundation or its equivalent can be exempted from taking the Reinforcement Mathematics, provided that the Mathematics offered at that programme level is equivalent / more	

LEVEL	ENTRY REQUIREMENT	ENGLISH COMPETENCY REQUIREMENT (INTERNATIONAL STUDENT)
	than the Additional Mathematics offered at an SPM level. iv. A pass in STPM (Science Stream) or its equivalent with a minimum grade of C (CGPA 2.00) in Mathematics subject and ONE (1) Science / ICT subject; **OR** v. Diploma in Computing (Level 4, MQF) or its equivalent with a minimum CGPA of 2.50; **OR** vi. Any Diploma in Science and Technology (Level 4, MQF) with a minimum CGPA of 2.75; **OR** viii. *Diploma Kemahiran Malaysia (DKM) / Diploma Vokasional Malaysia* (DVM) in Computing fields with a minimum CGPA of 2.50 subjected to HEP Senate / Academic Board's approval; **OR** ix. *Diploma Lanjutan Kemahiran Malaysia (DLKM)* in Computing fields with a minimum CGPA of 2.50 subjected to HEP Senate / Academic Board's approval. **Note:** ● Candidates for categories (v) until (ix) with a CGPA below 2.75 but more than 2.00 may be admitted subject to a thorough internal evaluation process.	
MASTER'S DEGREE (LEVEL 7, MQF)	**<u>Master's Degree by Coursework</u>** i. A Bachelor's degree (Level 6, MQF) in Computing or related fields with a minimum CGPA of 2.50, as accepted by the HEP Senate; **OR** ii. A Bachelor's degree (Level 6, MQF) in Computing or related fields or equivalent with a minimum CGPA of 2.00 can be accepted subject to a minimum of FIVE (5) years of working experience in the related fields and rigorous internal assessment; **OR** iii. Candidates without a qualification in the related fields or relevant working experience	Achieve a minimum score of 6.0 in the IELTS or equivalent. If a student does not meet this requirement, the HEP must offer English proficiency courses to ensure that the student's proficiency is sufficient to meet the needs of the programme.

LEVEL	ENTRY REQUIREMENT	ENGLISH COMPETENCY REQUIREMENT (INTERNATIONAL STUDENT)
	must undergo appropriate prerequisite courses as determined by the HEP and meet a minimum CGPA of 2.00 with minimum of FIVE (5) years of working experience in the related fields, and rigorous internal assessment; **OR** iv. Other qualifications equivalent to a Bachelor's degree (Level 6, MQF) in the field of Computing or related fields recognised by the Government of Malaysia must undergo appropriate prerequisite courses as determined by the HEP. **Master's Degree by Mixed Mode** i. A Bachelor's degree (Level 6, MQF) in Computing or related fields with a minimum CGPA of 2.75 or equivalent, as accepted by the HEP Senate; **OR** ii. A Bachelor's degree (Level 6, MQF) in Computing or related fields or equivalent with a minimum CGPA of 2.50 can be accepted subject to rigorous internal assessment; **OR** iii. A Bachelor's degree (Level 6, MQF) in Computing or related fields or equivalent with a minimum CGPA of 2.00 can be accepted subject to a minimum of FIVE (5) years of working experience in the related t fields and rigorous internal assessment; **OR** iv. Candidates without a qualification in the related fields or relevant working experience must undergo appropriate prerequisite courses as determined by the HEP and meet a minimum CGPA of 2.00 with a minimum of FIVE (5) years of working experience in the related fields and rigorous internal assessment; **OR** v. Other qualifications equivalent to a Bachelor's degree (Level 6, MQF) in the field of Computing or related fields recognised by the Government of Malaysia must undergo appropriate prerequisite courses as determined by the HEP **Master's Degree by Research** i. A Bachelor's degree (Level 6, MQF) in	

LEVEL	ENTRY REQUIREMENT	ENGLISH COMPETENCY REQUIREMENT (INTERNATIONAL STUDENT)
	Computing or related fields with a minimum CGPA of 3.00 or equivalent, as accepted by the HEP Senate **OR** ii. A Bachelor's degree (Level 6, MQF) in Computing or related fields or equivalent with a minimum CGPA of 2.75 can be accepted subject to rigorous internal assessment **OR** iii. A Bachelor's degree (Level 6, MQF) in Computing or related fields or equivalent with a minimum CGPA of 2.50 can be accepted subject to a minimum of FIVE (5) years of working experience in the related fields and rigorous internal assessment; **OR** iv. Candidates without a qualification in the related fields or relevant working experience must undergo appropriate prerequisite courses as determined by the HEP and meet a minimum CGPA of 2.50 with a minimum of FIVE (5) years of working experience in the related fields and rigorous internal assessment; **OR** v. Other qualifications equivalent to a Bachelor's degree (Level 6, MQF) in the field of Computing or related fields recognised by the Government of Malaysia must undergo appropriate prerequisite courses as determined by the HEP.	
DOCTORAL DEGREE (LEVEL 8, MQF)	*__**Doctoral Degree by Mixed Mode / Research / **Industrial Doctoral Degrees / Doctor of Philosophy by Retrospective or Prior Publications**__ i. A Master's degree (Level 7, MQF) in the field of Computing or related fields as accepted by the HEP Senate; **OR** ii. A Master's degree (Level 7, MQF) in non-Computing fields with a minimum of FIVE (5) years of working experience in the field of computing or related fields must undergo appropriate prerequisite courses as determined by the HEP; **OR** iii. A Master's degree (Level 7, MQF) in non-Computing fields with less than FIVE (5) years of	Achieve a minimum score of 6.0 in the IELTS or equivalent. If a student does not meet this requirement, the HEP must offer English proficiency courses to ensure that the student's proficiency is sufficient to meet the needs of the programme.

LEVEL	ENTRY REQUIREMENT	ENGLISH COMPETENCY REQUIREMENT (INTERNATIONAL STUDENT)
	working experience in the field of computing or related fields must undergo appropriate prerequisite courses as determined by the HEP and subject to rigorous internal assessment; **OR** iv. Other qualifications equivalent to a Master's degree in the field of Computing or related fields recognised by the Government of Malaysia must undergo appropriate prerequisite courses as determined by the HEP. **Notes:** **Applicable to all doctoral programmes, including doctoral degrees by retrospective or prior publication and TVET.* ***Refer to Standard Master's and Doctoral Degree.*	

Notes:

i. For candidates who have not passed the internal rigorous assessment, the HEP can determine for the candidate to be re-assessed for entry to the programme to pass preparatory courses as determined by the HEP before entering the programme, and subject to the HEP Senate / Academic Board's approval.

ii. Working experience can be cumulative industry engagement even before acquiring the required qualification for a particular level of study, however, it must be related to the level and content of the study.

iii. Bachelor's degree candidates who are registered for Master's degree programmes may apply to convert to the Doctoral degree programmes subject to the requirements in the Standard Master's and Doctoral Degree.

iv. Bachelor's degree candidates who are applying to doctoral programmes are subject to the requirements in the Standard Master's and Doctoral Degree.

v. Refer to *Surat JPT GS 1000-630(41). 9th December 2019 – Syarat Kompetensi Bahasa Inggeris Kepada Pelajar Antarabangsa* for equivalent English language assessments and scores.

vi. For Public Universities, refer to *Surat JPT.S(BPKP)2000/400/04/01 Jld.5(53), 20th November, 2019 - Pindaan syarat kelayakan minimum (Syarat am) Diploma TVET (DKM, DLKM, DVM) sebagai syarat kelayakan masuk ke program Ijazah Sarjana Muda di Universiti Awam (UA)*.

vii. For Private Higher Educational Institutions: Refer to Surat JPT/GS 1000-606 Jld. 2(23), 21st April, 2020 - *Kemasukan Pelajar Lulusan Diploma Kemahiran Malaysia (DKM), Diploma Lanjutan Kemahiran Malaysia (DLKM) dan Diploma Vokasional Malaysia (DVM) ke Peringkat Sarjana Muda (Tahap 6 MQF) atau yang setara dengannya di Institusi Pendidikan Tinggi Swasta.*

Accreditation of Prior Experiential Learning for Access

Accreditation of Prior Experiential Learning for Access (APEL.A) provides an alternative entry route to formal programmes of study from Certificate (Level 3, MQF) to Doctoral degree (Level 8, MQF) through recognition of learning and experiences, regardless of how and where they were acquired. For details, refer to the Guidelines to Good Practices: Accreditation of Prior Experiential Learning for Access (APEL.A) and Accreditation of Prior Experiential Learning for Micro-credentials (APEL.M).

5. ACADEMIC STAFF[4]

"As the quality of the academic staff is one of the most important components in assuring the quality of higher education, a HEP is expected to search for and appoint the best-suited candidates, to serve its programmes, in an open, transparent and fair manner. To achieve this, HEPs are expected to design and implement an academic staff search and recruitment practice that is as efficient as it is effective to achieve the desired results. Every programme must have an appropriately qualified and sufficient number of academic staffs, working in a conducive environment that attracts talented individuals. The numbers recruited have to be adequate for, and appropriate to, the needs of the programmes. The role of the academic staff in various activities has to be clarified in order to reflect a fair distribution of responsibilities. It is important for the HEP to provide a continuous staff development programme for its academic staff, for them to be current in their knowledge and skills, both in their chosen discipline as well as in their pedagogical skills." (COPPA 2nd Edition, 2017)

Table 5 provides the minimum requirements of the qualifications of academic staff and relevant staff ratios for the various MQF qualification levels in Computing. Besides possessing qualifications in the related field, HEPs must also ensure that academic staff are assigned courses based on their areas of expertise or relevant industry experience.

Table 5: Qualification requirement of academic staff

MQF LEVEL	MINIMUM REQUIREMENT	NOTE
CERTIFICATE (LEVEL 3, MQF)	● A Bachelor's degree (Level 6, MQF) in the Computing field; **OR** ● A Diploma (Level 4, MQF) in the Computing field: ○ With a minimum of FIVE (5) years of industry experience at a supervisory level in the subject taught; **OR** ○ Academic staff with professional certification in the Computing discipline **(the programme should not employ more than 30% of staff in this category)**.	● At least 60% of the academic staff are full-timers. ● Part-time staff may consist of industry practitioners or from academia. <u>Staff-student ratio:</u> ● 1:20 per programme.
DIPLOMA (LEVEL 4, MQF)		

[4] Standards in this area are best read together with the Guidelines to Good Practices: Academic Staff and the Guidelines: Academic Staff Workload, which are available on the MQA Portal, www.mqa.gov.my.

MQF LEVEL	MINIMUM REQUIREMENT	NOTE
BACHELOR'S DEGREE (LEVEL 6, MQF)	● A Master's degree (Level 7, MQF) in related fields AND a Bachelor's degree (Level 6, MQF) in Computing; **OR** ● A Bachelor's degree (Level 6, MQF) in Computing with FIVE (5) years of related industry experience in the subject taught (**the programme should not employ more than 30% of the staff in this category)**.	● At least 60% of the academic staff are full-timers. ● Part-time staff may consist of industry practitioners or from academia. <u>Staff-student ratio:</u> ● 1:15 per programme.
MASTER'S DEGREE (LEVEL 7, MQF)	**<u>By Coursework and Mixed Mode</u>** **Teaching staff*** ● A Doctoral degree (Level 8, MQF) AND a Master's degree** (Level 7, MQF) in related fields AND a Bachelor's degree (Level 6, MQF) in Computing; **OR** ● A Master's degree (Level 7, MQF) in Computing or related fields AND at least FIVE (5) years of teaching experience and research / project consultation / industry experience. ● Teaching staff from the industry or practitioner must have at least a Bachelor's degree in Computing and at least TEN (10) years of experience in Computing or related fields at a level appropriate for courses to teach practical / professional / hands-on components (**the programme should not employ more than 30% of the staff in this category)**. **For the research method course, staff must have a Doctoral degree in Computing or related fields with at least TWO (2) years of teaching experience.* ***Those without a Master's degree must have a Doctoral and Bachelor's degree in Computing.* **(Principal Supervisor)** ● A Doctoral degree (Level 8, MQF) AND Master's degree (Level 7, MQF) AND Bachelor's degree (Level 6, MQF) in Computing; **OR**	● At least 60% of the academic staff are full-timers. ● At least 70% of the teaching staff has a Doctoral degree qualification. ● Part-time staff may consist of industry practitioners or academia from other universities. ● The supervisors must go through structured supervisor training. <u>Staff-student ratio (Coursework):</u> ● Academic staff-student ratio – 1:15. ● Academic staff-student ratio – 1:10 (project and dissertation supervision). <u>Staff-student ratio (Research):</u> ● Principal supervisor-student ratio – 1:7 for both master's and doctoral students by research and mixed mode. ● Maximum number of postgraduate students by research per supervisor should not exceed 15. ● The principal supervisor must be a full-time staff. For supervision, the principal supervisor must be from the Computing field.

MQF LEVEL	MINIMUM REQUIREMENT	NOTE
	● A Master's degree (Level 7, MQF) in Computing with at least FIVE (5) years of teaching experience and research / project consultation / industry experience. **(Co-Supervisor)** ● A Doctoral degree (Level 8, MQF) in Computing or relevant fields; **OR** ● A Master's degree (Level 7, MQF) in Computing or relevant fields with at least FIVE (5) years of teaching experience and research / project consultation / industry experience. ● A co-supervisor from the industry or who is a practitioner must have at least a Bachelor's degree and at least FIVE (5) years of experience in the field at a level appropriate for the dissertation. **<u>By Research</u>** **(Principal supervisor)** ● A Doctoral degree (Level 8, MQF) in Computing; **OR** ● A Master's degree (Level 7, MQF) in Computing with at least FIVE (5) years of teaching experience and research and has co-supervised master's candidate. **(Co-supervisor)** ● A Doctoral degree (Level 8, MQF) in Computing or relevant fields; **OR** ● A Master's degree (Level 7, MQF) in Computing or relevant fields with at least ONE (1) year of teaching experience with experience in research / project consultation / industry experience, and required approval of the HEP Senate.	

MQF LEVEL	MINIMUM REQUIREMENT	NOTE
DOCTORAL DEGREE (LEVEL 8, MQF)	**By Mixed Mode and Research** **Teaching Staff*, **** ● A Doctoral degree (Level 8, MQF) in Computing with at least TWO (2) years of teaching experience; **OR** ● A Master's degree (Level 7, MQF) in Computing with at least SEVEN (7) years of teaching experience; **OR** ● A Master's degree (Level 7, MQF) in Computing with at least TEN (10) years of project consultation / industry experience, and required approval of the HEP Senate **(only for teaching staff from industry / practitioner).** **For computing courses only.* ***For the research method course, staff must have a Doctoral degree in Computing or related fields with at least TWO (2) years of teaching experience.* **Supervision** **(Principal supervisor)** ● A Doctoral degree in Computing (Level 8, MQF) with at least TWO (2) years of teaching experience and research and has supervised doctoral or master's candidates to completion (Mixed mode / Research mode). **(Co-supervisor)** ● A Doctoral degree in Computing (Level 8, MQF) or relevant fields with at least TWO (2) years of teaching experience and research and has supervised doctoral or master's candidates to completion; **OR** ● A Master's degree (Level 7, MQF) in Computing or relevant fields with FIVE (5) years of teaching experience with extensive experience in research / project consultation / industry experience, and required approval of the HEP Senate; **OR**	● At least 60% of the academic staff are full-timers. ● At least 70% of the teaching staff must have a doctoral degree qualification. ● The principal supervisor must be a full-time staff. ● Part-time staff may consist of industry practitioners or academia from other universities. ● The supervisors must go through structured supervisor training. Staff-student ratio: ● Principal supervisor-student ratio – 1:7 for both master's and doctoral students by research and mixed mode. ● Maximum number of postgraduate students by research per supervisor should not exceed 15.

MQF LEVEL	MINIMUM REQUIREMENT	NOTE
	● A Master's degree (Level 7, MQF) in Computing or relevant fields with at least TEN (10) years of project consultation / industry experience, and required approval of the HEP Senate **(only for co-supervisor from industry / practitioner).**	

Notes:

i. HEPs can hire full-time Subject Specialists for all levels who have at least a minimum of 10 years of industry experience and notable or exceptional talent in the Computing discipline as approved by the Board of Faculty / Senate.

ii. A candidate without a Bachelor's degree but with a Master's degree obtained through the APEL.A route may be accepted as academic staff by considering the related industry experience gained.

iii. Experience can be cumulative experience even before acquiring the required qualification for a particular level of study, however, it must be related to the level and content of the study.

iv. Related fields refer to any discipline from Science, Technology, Engineering and Mathematics.

Academic Staff Development

In order to deliver quality programmes and produce marketable graduates, competent qualified academic staff must be employed. Hence, HEPs must ensure that the academic qualifications of their academic staff are accredited by the relevant accreditation bodies.

It would also be an advantage for the HEPs to hire those with certain years of working experience to reflect on their intellectual maturity and enrich the learning experience of the students.

The HEPs must commit to providing staff with development opportunities to ensure that their staff are able to contribute fully to their vision and mission. Therefore, the **HEPs must provide the academic staff with at least 40 hours per year of Continuous Professional Development (CPD) programmes** to enhance their expertise and skills in teaching, learning, assessment and research. The CPD may include participating in training, workshops and conferences; pursuing academic / professional qualifications; engaging in self-directed studies; coaching / mentoring / tutoring; and performing industrial attachments, consultancies and community services. Part-time and / or contract staff should also be considered in the CPD programmes.

6. EDUCATIONAL RESOURCES

“Adequate educational resources are necessary to support the teaching and learning activities of a programme. These include all the required academic and instructional expertise, physical facilities, information and communication technologies, research facilities and finance.” (COPPA 2nd Edition, 2017)

For Computing programmes, HEPs are required to provide sufficient resources conducive to supporting teaching and learning in the field. Lecture and tutorial rooms, technical support / facilities and sufficient space to accommodate student-centred learning must be provided according to the current needs. For research in postgraduate programmes, candidates should be provided with a conducive work area.

Educational resources recommended for Computing programmes include:

i. Sufficient qualified experts in the Computing field
ii. Technical support
iii. Reliable and adequate Computing facilities / infrastructure
iv. Reliable and adequate Internet access
v. Lecture / tutorial rooms (with sufficient audio-visual facilities)
vi. Library / resource centre (including online resources for teaching and research) with up-to-date resources
vii. Standard-sized working space / station (with access to the internet) throughout their studies
viii. Sufficient access to relevant software according to the needs of the programmes and students
ix. Sufficient financial allocation for exhibition / publication / conference
x. Student lounge (near to student working space)
xi. Facilities and equipment for students with disabilities

All above-mentioned facilities must meet the minimum health and safety standards and special needs.

All studios / workshops / classrooms / labs / workstations must be equipped with appropriate space, accessories, equipment with enough computers (if related to the courses) and working areas, and they must meet the minimum safety standards.

All Computing programmes run by the HEP must have the appropriate reading references and materials accessible to the staff and students and must be available in the HEP's library or resource room.

The programme must have sufficient, relevant and appropriate physical facilities and training resources at the commencement of the programme to ensure its effective delivery, including facilities for practical-based programmes and those with special needs.

All shared facilities between the industry and HEPs in accordance to the requirements of the programme as stated in the Memorandum of Understanding (MoU) / Memorandum of Agreement (MoA) / Letter of Agreement (LoA) must be verified and approved by MQA.

7. PROGRAMME MANAGEMENT

“There are many ways of administering an educational institution and the methods of management differ between Higher Education Providers (HEPs). Nevertheless, governance that reflects the collective leadership of an academic organisation must emphasise excellence and scholarship. At the departmental level, it is crucial that the leadership provides clear guidelines and directions, builds relationships amongst the different constituents based on collegiality and transparency, manages finances and other resources with accountability, forges a partnership with significant stakeholders in educational delivery, research and consultancy, and dedicates itself to academic and scholarly endeavours. Whilst formalised arrangements can protect these relationships, they are best developed by a culture of reciprocity, mutuality and open communication.” (COPPA 2nd Edition, 2017)

This document will not raise issues pertaining to governance and administration as these are at the institutional level rather than the programme level. In this PS, academic leadership is largely focused on suitably qualified persons in the Computing field to carry out the necessary curriculum monitoring, review and assessment. The leaders of the programmes should demonstrate knowledge of the field and the attributes of good ethical values in work practices. It is advisable that leaders of programmes have industry experience or relevant professional certification.

A person holding the programme leadership position must:

i. have related academic qualifications and experience in the area of study.
ii. have a broad-based view of computing and perception of the industry and its impact on the environment and society.
iii. have the ability to inspire others to perform at their full potential.
iv. have the ability to listen and communicate effectively with sensitivity to both individuals and groups.
v. be able to show a strong commitment to translating the organisation’s aspirations through initiatives consistent with the organisation’s purposes.
vi. be able to make sound judgements based on relevant input or information.
vii. be flexible to the changing demands and pressures from key stakeholders to achieve individual and organisational goals.
viii. be able to promote continuous learning among staff and students.
ix. be able to establish a constructive mechanism for collaboration with stakeholders.

The programme leader, i.e., Programme Coordinator, Head of Programme or equivalent positions, must meet the qualification and experience requirements as stated in **Table 7**.

Table 7: Criteria for selection of programme leader

MQF LEVEL	MINIMUM REQUIREMENT
CERTIFICATE (LEVEL 3, MQF)	Bachelor's degree (Level 6, MQF) in Computing and FIVE (5) years of academic experience.
DIPLOMA (LEVEL 4, MQF)	
BACHELOR'S DEGREE (LEVEL 6, MQF)	Master's degree (Level 7, MQF) AND Bachelor's degree (Level 6, MQF) in Computing and THREE (3) years of academic experience.
MASTER'S DEGREE (LEVEL 7, MQF)	Doctoral degree (Level 8, MQF) AND Master's degree* (Level 7, MQF) AND Bachelor's degree (Level 6, MQF) in Computing and THREE (3) years of academic experience; **OR** Master's degree (Level 7, MQF) AND Bachelor's degree (Level 6, MQF) in Computing with TEN (10) years of related experience, including THREE (3) years of academic experience. **Those without a Master's degree must have a Doctoral degree and a Bachelor's degree in Computing.*
DOCTORAL DEGREE (LEVEL 8, MQF)	Doctoral degree (Level 8, MQF) AND Master's degree* (Level 7, MQF) AND Bachelor's degree (Level 6, MQF) in Computing and THREE (3) years of academic experience **Those without a Master's degree must have a doctoral and a Bachelor's degree in Computing.*

The programme must be supported by sufficient support staff. The criteria and responsibilities of the school, faculty or department academic leadership must be well documented. The management must institute a quality assurance system that is supported by sufficient administrative and support staff. And the effective deployment of available resources to implement academic and non-academic activities, such as the graduate employment of the programme, needs to be in line with the dynamic needs of the industry (refer to Appendix 6).

Note:

- The appointment for the Management of the Faculty, Academic Centre, Department, School, etc., requires the HEP's to document the process of appointments accordingly as a policy paper to support its structural frameworks and represent appropriately towards the governing of the programme.

8. PROGRAMME MONITORING, REVIEW AND CONTINUAL QUALITY IMPROVEMENT[5]

"Quality enhancement calls for programmes to be regularly monitored, reviewed and evaluated. These include the responsibility of the department to monitor, review and evaluate the structures and processes and curriculum components, as well as the student's progress, employability and performance.

In addition, feedback from multiple sources such as students, alumni, academic staff, employers, professional bodies and informed citizens are encouraged to assists in enhancing the quality of the programme.

Measures of student performances include the average study duration, assessment scores, passing rate in examinations, success and dropout rates, student and alumni reports about their learning experience, as well as time spent by students in areas of special interest. Evaluation of student performances in examinations can reveal very useful information. For example, if the student selection has been done correctly, a high failure rate in a programme would indicate something amiss in the curriculum content, teaching-learning activities or assessment system. The programme committees need to monitor the performance rate in each course and investigate if the rate is too high or too low.

Student feedback, for example, through questionnaires and representation in programme committees, is useful for identifying specific problems and for continual improvement of the programme.

One method to evaluate programme effectiveness is a longitudinal study of the graduates. The department should have mechanisms for monitoring the performance of its graduates and for obtaining the perceptions of society and employers on the strengths and weaknesses of the graduates and to respond appropriately." (COPPA 2nd Edition, 2017)

"Comprehensive monitoring and review of the programme for its improvement are to be carried out with a proper mechanism, considering feedback from various parties. The committee responsible for this should be granted adequate autonomy to carry out its responsibility

[5] Standards in this area are best read together with the Guidelines to Good Practices: Monitoring, Reviewing and Continually Improving Institutional Quality and the Guidelines on Terms Used for External Examiner, External Advisor and Advisory Board, which are available on the MQA Portal: www.mqa.gov.my.

effectively. It is desirable that the departments work in association with the HEP's central Quality Assurance Unit to ensure objectivity." (COPPA 2nd Edition, 2017)

The HEPs are expected to provide evidence of their ability to keep pace with the changes in the field of Computing and the requirements of the stakeholders. These may be demonstrated by, but are not limited, to the following:

i. The department must have a Quality Assurance (QA) unit for internal quality assurance of the department to work hand-in-hand with the QA unit of the HEP;
ii. A comprehensive curriculum review should be conducted at least once every 3 to 5 years. However, updating the curriculum to keep pace with current developments should be conducted at more regular intervals;
iii. Compulsory appointment of external advisors and examiners (academicians) who are qualified in the related fields to assure the quality of the students of the Bachelor's degree (Level 6, MQF) and above programmes;
iv. Continual benchmarking against top universities at the national and international levels.
v. Linkages with related professional bodies, government agencies and industry;
vi. Engagement with industry practitioners through appointment as a member of the Board of Studies, appointment of adjunct positions, guest speakers; etc
vii. Annual dialogue sessions with stakeholders;
viii. Active participation of academic staff at relevant conferences, seminars, workshops and short courses;
ix. Presentations by invited speakers, local or international;
x. Organising conferences, seminars and workshops;
xi. Encouraging international exchange among students and staff;
xii. Continuous review of industrial attachment practices and records.

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APPENDIX 1

LIST OF PANEL MEMBERS

NO.	PANEL MEMBER	ORGANISATION
1.	Professor Dr. Hjh Azlinah Mohamed (Chairman)	Fakulti Sains Komputer dan Matematik Universiti Teknologi MARA, Shah Alam Institut Analitik Data Raya & Kepintaran Buatan Universiti Teknologi MARA, Shah Alam
2.	Associate Professor Ts. Dr. Zulkefli Mansor (Co-Chairman / Standard Writer)	Fakulti Teknologi dan Sains Maklumat Universiti Kebangsaan Malaysia
3.	Associate Professor Ts. Dr. Mohamad Fadli Zolkipli	Pusat Pengajian Komputeran Universiti Utara Malaysia
4.	Associate Professor Ts. Dr. Jafreezal Jaafar	Fakulti Sains dan Teknologi Maklumat Universiti Teknologi Petronas
5.	Mr. Muhammad Fauzi Abdullah	Jabatan Teknologi Maklumat dan Komunikasi Politeknik Sultan Idris Shah
6.	Mr. Azmi Ahmad	Malaysian Institute of Information Technology Universiti Kuala Lumpur
7.	Dr. Dzaharudin Mansor	Persatuan Industri Komputer dan Multimedia Malaysia (PIKOM) Wakil industri Tempoh pelantikan: September 2021 - Mac 2022
8.	Professor. Dato' Dr. Bahari Belaton	Pusat Pengajian Sains Komputer Universiti Sains Malaysia Wakil Majlis Dekan ICT Universiti Awam (MADICT)
9.	Mr. Nik Naharuddin Mohd Nasir	Malaysia Digital Economy Corporation (MDEC)
10.	Mr Ts. Lee Hwee Hsiung	Jabatan Pembangunan Profesional Keselamatan Siber (Cybersecurity)
11.	Wakil Jabatan Pengajian Tinggi	Bahagian Kecemerlangan Akademik, Kementerian Pendidikan Tinggi (KPT)

APPENDIX 2

LIST OF ORGANISATIONS INVOLVED IN THE STAKEHOLDER WORKSHOPS

1. Higher Education Provider

Universiti Teknologi MARA (UiTM)
Universiti Kebangsaan Malaysia (UKM)
Universiti Utara Malaysia (UUM)
Universiti Sains Malaysia (USM)
Universiti Teknologi Malaysia (UTM)
Universiti Putra Malaysia (UPM)
Universiti Teknologi Petronas (UTP)
Universiti Multimedia (MMU)
Universiti Teknikal Malaysia Melaka (UTEM)
Universiti Pertahanan Nasional Malaysia (UPNM)
Universiti Malaysia Terengganu (UMT)
Universiti Malaysia Pahang (UMP)
Universiti Malaysia Kelantan (UMK)
Universiti Malaysia Sabah (UMS)
Universiti Selangor (UNISEL)
Universiti Sains Islam Malaysia (USIM)
Universiti Sultan Zainal Abidin (UniSZA)
Universiti Tenaga Nasional (UNITEN)
Universiti Tunku Abdul Rahman (UTAR)
Universiti Kuala Lumpur (UniKL)
Universiti Islam Pahang Sultan Ahmad Shah (UNIPSAS)
Management and Science University (MSU)
Wawasan Open University (WOU)
Sunway University
AIMST University
SEGi University
UOW Malaysia KDU University College
Kolej Universiti Islam Antarabangsa Selangor (KUIS)
Kolej Universiti TATI (UC TATI)
Kolej Universiti Bestari (UC Bestari)
Universiti College of Technology Sarawak

Melaka International College of Science and Technology (MiCoST)

Kolej Teknologi Antarabangsa Cybernetics

FAME International College

2. Government Agency

Kementerian Pendidikan Tinggi (KPT)

Kementerian Sains, Teknologi dan Inovasi (MOSTI)

Jabatan Pengajian Politeknik Dan Kolej Komuniti (JPPKK)

Malaysian Administrative Modernisation and Management Planning Unit (MAMPU)

Malaysia Digital Economy Corporation (MDEC)

CyberSecurity Malaysia

Majlis Dekan ICT (MADICT)

3. Industry

PIKOM - The National Tech Association of Malaysia

Asia Mobiliti

AKATI Sekurity

Hemmersbach (Malaysia) Sdn Bhd

Polaris Net Sdn Bhd

Technological Association Malaysia

Assuring Group

Ramssol Group

Mobius Group

4. MQA Panel of Assessors (Computing)

5. MQA Officers

APPENDIX 3

CORE COMPUTING AREA

Core Computing Areas (CA) and their competencies for all disciplines of Computing at each level are shown below:

Core Computing area	Certificate	Diploma	Bachelor's Degree
Computer Architecture	● Identify hardware, software and network components and the subsystems used in a computer system. ● Identify interconnection between hardware, software and network to create a computer system. ● Apply an appropriate architecture that reflects the computer system. ● Demonstrate diagnostic and troubleshooting skills to solve hardware, software and networking-related issues.	● Explain the relationships between hardware components and the subsystems used in a computer system. ● Categorise the key features and services provided by different computer operating systems and hardware. ● Use network communication technology and the associated services to connect computer systems. ● Demonstrate diagnostic and troubleshooting skills to solve hardware, software and networking-related issues.	● Explain the relationships between hardware components and the subsystems used in a computer system. ● Categorise the key features and services provided by different computer operating systems and hardware. ● Use simulation tools for capture, synthesis and simulation to evaluate simple building blocks of a simple computer design. ● Evaluate the timing diagram behaviour of a simple processor implemented at the logic circuit level and develop a report expressing the findings. ● Write a simple program at the assembly / machine level for string processing and manipulation and for converting numerical data into hexadecimal form. ● Implement a fundamental high-level construct in both machine and assembly languages

Core Computing area	Certificate	Diploma	Bachelor's Degree
			and present the results to a group of peers.
Database Fundamentals	● Explain the database concept, technology and application. ● Describe the appropriate tool to design a relational database system for a simple problem. ● Show the feasibility of the design.	● Use an appropriate tool to design a relational database system for a substantial problem. ● Manage a fully functional relational database system based on an existing system design. ● Implement database systems project. ● Produce technical documentation.	● Design a relational database system for a substantial problem. ● Develop a fully functional relational and non-relational database system based on an existing system design. ● Configure and Deploy database systems project. ● Produce technical documentation. ● Secure a database.
Basic Mathematics	● Identify problems in any domain of interest that can be addressed mathematically. ● Find a mathematical formulation for identified problems. ● Demonstrate the ability to use basic techniques of counting and algorithms in computer science.	-	-
Network & Data Communication	● Describe networking principles and their protocols. ● Identify networking devices and operations. ● Use network communication technology and the associated services to connect computer systems.	● Describe networking principles and their protocols. ● Identify networking devices and operations. ● Describe the latest network technology, such as cloud computing. ● Design efficient network systems. ● Diagnose network systems.	● Describe different network standards, components and requirements of network protocols. ● Apply the latest network technology, such as cloud computing. ● Design efficient inter-network systems for specific tasks or problems. ● Troubleshoot inter-network systems. ● Explain different main issues related to network management.

Core Computing area	Certificate	Diploma	Bachelor's Degree
Operating Systems	● Explain the fundamental concept of operating systems. ● Describe Command-Line Interface (CLI)- and Graphical User Interface (GUI)-based operating systems, their functions and user interfaces related to the computing disciplines. ● Demonstrate the use of the related operating systems. ● Install and configure the appropriate operating system.	● Describe different operating systems, their functions and user interfaces. ● Explore the processes managed by an operating system. ● Demonstrate the use of various operating systems. ● Analyse appropriate techniques and technologies used in distributed and concurrent systems.	● Apply knowledge of computing theory and mathematics to solve problems in distributed and concurrent systems. ● Analyse modern operating systems, their functions and user interfaces. ● Implement software solutions within the system constraints of a target system, considering its abilities and constraints. ● Predict the behaviour of systems under random events using knowledge of probability and expectation.
Programming Fundamentals	● Describe programming language concepts. ● Develop appropriate algorithms based on a simple problem. ● Code appropriate algorithms in using an IDE according to the programming standard.	● Describe programming language concepts for procedural, object-oriented and event-driven programming. ● Develop appropriate algorithms based on a routine problem. ● Code appropriate algorithms in using an IDE according to the programming standard.	● Apply the knowledge of problem-solving using appropriate programming language concepts, such as procedural, object-oriented and event-driven programming. ● Develop appropriate algorithms based on a well-defined problem with some interacting factors for an optimised solution. ● Code appropriate algorithms according to the programming process and standard. ● Apply the debugging process.
Cybersecurity Fundamentals	● Describe the nature of cybercrime and its cyber ethics. ● Identify cyber security threats and hazards.	● Describe the nature of cybercrime and its cyber ethics. ● Identify cyber security threats and hazards.	-

Core Computing area	Certificate	Diploma	Bachelor's Degree
		● Explain the effectiveness of information assurance in cybercrime. ● Apply information assurance to overcome cyber security threats.	
System Analysis and Design Fundamentals	● Describe the appropriate concept, model, tool and techniques for System Analysis and Design. ● Describe the appropriate key deliverables of each phase in System Development Life Cycle (SDLC) activities. ● Understand in proposing a project development.	● Implement the appropriate model, tool and techniques concept of System Analysis and Design. ● Prepare the appropriate key deliverables of each phase in SDLC activities. ● Explain the appropriate process involve in the proposed project development. ● Use appropriate documentation for system analysis and design.	● Analyse and differentiate the appropriate model, tool and techniques concept of object-oriented and structural system analysis and design. ● Execute the appropriate key deliverables of each phase in SDLC activities. ● Apply the appropriate process involve in the proposed project development. ● Prepare appropriate documentation for system analysis and design.
Statistics and Probability	-	● Analyse events using probability theory and probability distributions. ● Describe statistics methods appropriate for the related areas in computing. ● Analyse statistics methods for problem-solving in the area of computing. ● Determine statistics method for problem-solving in the area of computing.	-
Ethics in Computing	-	● Understand the philosophical bases for computer ethics and social issues.	-

Core Computing area	Certificate	Diploma	Bachelor's Degree
		● Explain the reliability and safety of computer systems, protecting software and other intellectual property. ● Describe privacy and information issues and strategies on the impact and control of computer technology. ● Apply professional codes of ethics.	
Discrete Mathematics	-	● Examine set theory and functions applicable to software engineering. ● Analyse mathematical structures of objects using graph theory. ● Investigate solutions to problem situations using the application of Boolean algebra. ● Explore applicable concepts within abstract algebra.	-
Calculus and Algebra	-	● Use applied number theory in practical computing scenarios. ● Determine solutions of graphical examples using geometry and vector methods. ● Evaluate problems concerning differential and integral calculus.	-

APPENDIX 4

KNOWLEDGE AREA

Discipline Core of Knowledge Area (KA) and their competencies for all areas of Computing are shown in the Tables below. The development of a programme must adhere to the specific requirements of the chosen discipline:

- **INFORMATION TECHNOLOGY**
  The body of knowledge for the Information Technology discipline and corresponding detail competencies are listed below. For more information, refer to "IT 2017: Curriculum Guidelines for Baccalaureate Degree Programs in Information Technology".

Knowledge Area	Certificate	Diploma	Bachelor's Degree
Cybersecurity	-	● Evaluate the purpose and function of cybersecurity technology, identifying the tools and systems that reduce the risk of data breaches while enabling vital organisation practices. ● Implement systems, apply tools and use concepts to minimise the risk to an organisation's cyberspace to address cybersecurity threats.	● Evaluate the purpose and function of cybersecurity technology, identifying the tools and systems that reduce the risk of data breaches while enabling vital organisation practices. ● Implement systems, apply tools and use concepts to minimise the risk to an organisation's cyberspace to address cybersecurity threats. ● Use a risk management approach for responding to and recovering from a cyber-attack on a system that contains high-value information and assets, such as an email system. ● Develop policies and procedures needed to respond to and remediate a cyber-attack on a credit card system and describe a plan to restore functionality to the infrastructure.
Global Professional Practice	-	-	● Analyse the importance of communication skills in a team environment and determine how these skills contribute to the optimisation of organisation goals. ● Evaluate the specific skills necessary for maintaining continued employment in an

Knowledge Area	Certificate	Diploma	Bachelor's Degree
			information technology career that involves system development in an environmental context. ● Develop information technology policies within an organization that include privacy, legal and ethical considerations related to a corporate setting. ● Evaluate related issues facing an information technology project and develop a project plan using a cost/benefit analysis, including risk considerations in creating an effective project plan from its start to its completion.
Information Management	-	● Express how the growth of the internet and demands for information have changed data handling and transactional and analytical processing, leading to the creation of special-purpose databases. ● Design and implement a physical model based on appropriate organisation rules for a given scenario, including the impact of normalisation and indexes. ● Create working Structured Query Language (SQL) statements for simple and intermediate queries to create and modify data and database objects to store, manipulate and analyse enterprise data.	● Express how the growth of the internet and demands for information have changed data handling and transactional and analytical processing, leading to the creation of special-purpose databases. ● Design and implement a physical model based on appropriate organisation rules for a given scenario, including the impact of normalisation and indexes. ● Create working SQL statements for simple and intermediate queries to create and modify data and database objects to store, manipulate and analyse enterprise data. ● Analyse how data fragmentation, replication and allocation affect database performance in an enterprise environment.

Knowledge Area	Certificate	Diploma	Bachelor's Degree
			● Perform major database administration tasks, such as creating and managing database users, roles and privileges, and backup and restore database objects to ensure organisational efficiency, continuity and information security.
Integrated Systems Technology	● Describe the concept of integration at the system level. ● Identify how to code and store characters, images and other forms of data in computers. ● Show why data conversion is often a necessity when merging disparate computing systems. ● Show how a commonly used intersystem communication protocol works, including its advantages and disadvantages.	● Illustrate how to code and store characters, images and other forms of data in computers. ● Show why data conversion is often a necessity when merging disparate computing systems. ● Show how a commonly used intersystem communication protocol works, including its advantages and disadvantages. ● Design, debug and test a script that includes selection, repetition and parameter passing.	● Illustrate how to code and store characters, images and other forms of data in computers. ● Show why data conversion is often a necessity when merging disparate computing systems. ● Show how a commonly used intersystem communication protocol works, including its advantages and disadvantages. ● Design, debug and test a script that includes selection, repetition and parameter passing. ● Illustrate the goals of secure coding and show how to use these goals as guideposts in dealing with preventing buffer overflow, wrapper code and securing method access.
Networking	● Analyse and compare the characteristics of various communication protocols and how they support application requirements within a telecommunication system. ● Analyse and compare several networking	● Analyse and compare the characteristics of various communication protocols and how they support application requirements within a telecommunication system. ● Analyse and compare several networking topologies in terms of robustness, expandability and throughput used within a cloud enterprise.	● Analyse and compare the characteristics of various communication protocols and how they support application requirements within a telecommunication system. ● Analyse and compare several networking topologies in terms of robustness, expandability and throughput used within a cloud enterprise.

Knowledge Area	Certificate	Diploma	Bachelor's Degree
	topologies in terms of robustness, expandability and throughput used within a cloud enterprise. ● Describe different network standards, components and requirements of network protocols within a distributed computing setting.	● Describe different network standards, components and requirements of network protocols within a distributed computing setting.	● Describe different network standards, components and requirements of network protocols within a distributed computing setting. ● Produce managerial policies to address server breakdown issues within a banking system. ● Explain different main issues related to network management.
Platform Technologies	-	● Describe how the historical development of hardware and operating system computing platforms produced the computing systems we have today. ● Show how to choose among operating system options and install at least one operating system on a computer device.	● Describe how the historical development of hardware and operating system computing platforms produced the computing systems we have today. ● Show how to choose among operating system options and install at least one operating system on a computer device. ● Justify the need for power and heat budgets within an information technology environment, and document the factors needed when considering power and heat in a computing system. ● Produce a block diagram, including interconnections, of the main parts of a computer, and illustrate methods used on a computer for storing and retrieving data.
Cloud Computing	-	● Analyse the meaning of cloud computing and understand the different cloud service categories. ● Categorise cloud service types and be aware of privacy	● Analyse the meaning of cloud computing and understand the different cloud service categories. ● Categorise cloud service types and be aware of privacy regulation impact on cloud

Knowledge Area	Certificate	Diploma	Bachelor's Degree
		regulation impact on cloud application requirements.	application requirements. ● Consider contract negotiations needed for cloud service delivery and develop the skills necessary to assess security breaches and their impact on the organisation. ● Analyse when to use cloud applications and how architecture affects performance. ● Develop a cloud application with a user interface and understand data components.
Discrete Structure	-	● Present to a peer group some practical examples of an appropriate set, function or relation model, and interpret the associated operations and terminology in context. ● Use symbolic propositional and predicate logic to model a real-life industry application by applying formal methods (e.g., calculating the validity of formulae and computing normal forms to the symbolic logic). ● Apply rules of inference to construct proofs and present results to a group of professionals, using appropriate proofs or logical reasoning to solve a strategic problem.	● Present to a peer group some practical examples of an appropriate set, function or relation model, and interpret the associated operations and terminology in context. ● Use symbolic propositional and predicate logic to model a real-life industry application by applying formal methods (e.g., calculating the validity of formulae and computing normal forms to the symbolic logic). ● Apply rules of inference to construct proofs and present results to a group of professionals, using appropriate proofs or logical reasoning to solve a strategic problem. ● Map real-world applications to appropriate counting formalisms and apply basic counting theories (e.g., counting arguments, the pigeonhole principle,

Knowledge Area	Certificate	Diploma	Bachelor's Degree
			modular arithmetic, compute permutations and combinations of a set) to solve an industry problem. ● Analyse an industry problem to determine underlying recurrence relations and present the solution to professionals by using a variety of basic recurrence relations. ● Model a real-world problem using appropriate graphing strategies (e.g., trees, traversal methods for graphs and trees, and spanning trees of a graph) and determine whether two graph approaches are isomorphic. ● Calculate different probabilities of dependent or independent events and expectations of random variables to solve a problem, and present to a group of peers the ways to compute the variance for a given probability distribution.
System Paradigms	● Demonstrate a procurement process for software and hardware acquisition. ● Explain the procedures one might use for testing the critical issues that could affect information technology system performance.	● Justify the way information technology systems within an organisation can represent stakeholders using different architectures and the ways these architectures relate to a system lifecycle. ● Demonstrate a procurement process for software and hardware acquisition and explain the procedures one might use for testing the critical issues that could affect information	● Justify the way information technology systems within an organisation can represent stakeholders using different architectures and the ways these architectures relate to a system lifecycle. ● Demonstrate a procurement process for software and hardware acquisition and explain the procedures one might use for testing the critical issues that could affect information

Knowledge Area	Certificate	Diploma	Bachelor's Degree
		technology system performance. ● Evaluate integration choices for middleware platforms and demonstrate how these choices affect testing and evaluation within the development of an information technology system.	technology system performance. ● Evaluate integration choices for middleware platforms and demonstrate how these choices affect testing and evaluation within the development of an information technology system. ● Use knowledge of information technology and sensitivity to the goals and constraints of the organisation to develop and monitor effective and appropriate system administration policies within a government environment. ● Develop and implement procedures and employ technologies to achieve administrative policies within a corporate environment. ● Organise personnel and information technology resources into appropriate administrative domains in a technical centre. ● Use appropriate and emerging technologies to improve the performance of systems and discover the cause of performance problems in a system.
Software Fundamentals	-	● Use multiple levels of abstraction and select appropriate data structures to create a new program that is socially relevant and requires teamwork. ● Evaluate how to write a program in terms of the program style, intended behaviour on specific inputs, the correctness	● Use multiple levels of abstraction and select appropriate data structures to create a new program that is socially relevant and requires teamwork. ● Evaluate how to write a program in terms of the program style, intended behaviour on specific inputs, the correctness

Knowledge Area	Certificate	Diploma	Bachelor's Degree
		of program components and descriptions of program functionality.	of program components and descriptions of program functionality. ● Develop algorithms to solve a computational problem and explain how programs implement algorithms in terms of instruction processing, program execution and running processes.
User Experience Design	● Describe user interface design concepts based on stakeholder needs. ● Apply interactive techniques in an application with related tools.	● Design an interactive application, applying a user-centred design cycle and related tools and techniques (e.g., prototyping), aiming at usability and relevant user experience within a corporate environment. ● For a case of user-centred design, analyse and evaluate the context of use, stakeholder needs, state-of-the-art interaction opportunities, and envisioned solutions while considering user attitude and applying relevant tools and techniques (e.g., heuristic evaluation), aiming at universal access and inclusiveness, and showing a responsive design attitude by considering assistive technologies and culture-sensitive design. ● For evaluation of user-centred design, articulate evaluation criteria and compliance with relevant standards.	● Design an interactive application, applying a user-centred design cycle and related tools and techniques (e.g., prototyping), aiming at usability and relevant user experience within a corporate environment. ● For a case of user-centred design, analyse and evaluate the context of use, stakeholder needs, state-of-the-art interaction opportunities, and envisioned solutions while considering user attitude and applying relevant tools and techniques (e.g., heuristic evaluation), aiming at universal access and inclusiveness, and showing a responsive design attitude by considering assistive technologies and culture-sensitive design. ● For evaluation of user-centred design, articulate evaluation criteria and compliance with relevant standards. ● In design and analysis, apply knowledge from related disciplines, including human information processing, anthropology and ethnography, and

Knowledge Area	Certificate	Diploma	Bachelor's Degree
			ergonomics / human factors. ● Apply experience design for a service domain related to several disciplines, focusing on multiple stakeholders and collaborating in an interdisciplinary design team.
Web and Mobile Systems	● Explain the concept of web and mobile frameworks and technologies. ● Identify a responsive web application utilising a web framework and technologies. ● Show a mobile app that is usable, efficient and secure on more than one device.	● Design a responsive web application utilising a web framework and presentation technologies in support of a diverse online community. ● Develop a mobile app that is usable, efficient and secure on more than one device.	● Design a responsive web application utilising a web framework and presentation technologies in support of a diverse online community. ● Develop a mobile app that is usable, efficient and secure on more than one device. ● Analyse a web or mobile system and correct security vulnerabilities. ● Implement storage, transfer and retrieval of digital media in a web application with appropriate file, database or streaming formats. ● Describe the major components of a web system and how they function together, including the web server, database, analytics and front end.

- **INFORMATION SYSTEM**

  The body of knowledge for the Information System discipline and corresponding detail competencies are listed below. For more information, refer to “IS 2020: A Competency Model for Undergraduate Programs in Information Systems”.

Knowledge Area	Certificate	Diploma	Bachelor’s Degree
Foundational Information System	● Explain the components, elements and operations of an information system. ● Describe the dimensions, characteristics and value of quality information. ● Explain the roles, responsibilities and characteristics of the information system profession.	● Classify the components, elements, operations and impact of an information system. ● Interpret the dimensions, characteristics and value of quality information. ● Explain the roles, responsibilities and characteristics of the information system profession. ● Recommend techniques for using information and knowledge for business decision-making and strategic value. ● Demonstrate an ability to solve basic computational and design problems using information system development with appropriate methodologies, software tools and innovative methods for improving processes and organisational change.	● Classify the components, elements, operations and impact of an information system. ● Interpret the dimensions, characteristics and value of quality information. ● Explain the roles, responsibilities and characteristics of the information system profession. ● Recommend techniques for using information and knowledge for business decision-making and strategic value. ● Analyse a business case and critique appropriate information system solutions to common business problems, based on the different components, elements, types and levels of the information system. ● Critique and recommend Enterprise Systems for a given business problem and processes. ● Identify techniques for transmitting and securing information in an organisation. ● Demonstrate an ability to solve basic computational and design problems using information system development with appropriate methodologies, software tools and innovative methods for improving processes and organisational change.

Knowledge Area	Certificate	Diploma	Bachelor's Degree
Data / Information Management	-	● Query the relational model. ● Design relational databases. ● Programme database systems using functions and triggers.	● Query the relational model. ● Design relational databases. ● Programme database systems using functions and triggers. ● Secure a database. ● Compare trade-offs of different concurrency modes. ● Develop non-relational models.
Information Technology Infrastructure	● Explain key infrastructure concepts, including how it functions, how to define critical functions and how to plan and manage infrastructure. ● Explain the components of information technology infrastructure solutions from client / server and network hardware (including wireless and wired).	● Explain key infrastructure concepts, including how it functions, how to define critical functions and how to plan and manage infrastructure. ● Explain the principles of layered network architectures. ● Explain the components of information technology infrastructure solutions from client / server and network hardware (including wireless and wired). ● Explain the principles of network software and configuration. ● Explain network protocols and their configuration.	● Explain key infrastructure concepts, including how it functions, how to define critical functions and how to plan and manage infrastructure. ● Explain the principles of layered network architectures. ● Explain the components of information technology infrastructure solutions from client / server and network hardware (including wireless and wired). ● Explain the principles of network software and configuration. ● Explain network protocols and their configuration. ● Illustrate a clear understanding of security principles pertaining to networks. ● Examine and critique information technology infrastructure for organisations. ● Examine and critique information technology server architecture (both physical and cloud-based). ● Explain concepts of Enterprise Architecture.
Secure Computing	-	● Explain the purpose of cryptography and how it	● Explain the purpose of cryptography and how it

Knowledge Area	Certificate	Diploma	Bachelor's Degree
		can be used in data communications. ● Describe the concepts of authentication, authorisation, access control and data integrity, and how they help to enhance data security. ● Explain the security requirements that are important during software design. ● Describe risk management techniques to identify and prioritise risk factors for information assets and how risk is assessed.	can be used in data communications. ● Describe the concepts of authentication, authorisation, access control and data integrity, and how they help to enhance data security. ● Explain the security requirements that are important during software design. ● Analyse the concepts of identification, authentication and access authorisation in the context of protecting people and devices. ● Analyse the importance of social media privacy and security. ● Illustrate how cyberattacks work, how to avoid them and how to counteract their malicious consequences. ● Describe risk management techniques to identify and prioritise risk factors for information assets and how risk is assessed. ● Illustrate the types of security laws, regulations and standards in which an organisation operates.
Systems Analysis & Design	-	● Explain what systems are and how they are developed. ● Demonstrate the SDLC phases and activities. ● Identify SDLC Models (Agile, Waterfall, V-shaped, iterative, spiral, etc.). ● Work effectively in a team environment. ● Describe data modelling techniques. ● Describe the roles and responsibilities of the participants in the SDLC.	● Explain what systems are and how they are developed. ● Demonstrate the SDLC phases and activities. ● Identify SDLC Models (Agile, Waterfall, V-shaped, iterative, spiral, etc.). ● Work effectively in a team environment. ● Describe data modelling techniques. ● Describe the roles and responsibilities of the participants in the SDLC.

Knowledge Area	Certificate	Diploma	Bachelor's Degree
			● Explain the common ways projects fail and how to avoid these failures. ● Identify Enterprise Architecture concepts related to the SDLC phases.
Application Development / Programming	***Programming*** ● Develop data storage strategies using primitive data types in a computer's volatile memory. ● Apply data transformations using arithmetic, assignment and transposition operators. ● Develop predicate expressions using relational and logical operators. ● Express algorithmic problem-solving using sequence, selection and repetition structures. ***Application Development*** ● Conduct a systematic requirements analysis to determine the basic facts used to organise the application of programming effort to solve a problem or reach a goal. ● Formalise and communicate requirements in a manner that is comprehensible for all stakeholders that will determine the success of the software system.	***Programming*** ● Develop data storage strategies using primitive data types in a computer's volatile memory. ● Apply data transformations using arithmetic, assignment and transposition operators. ● Develop predicate expressions using relational and logical operators. ● Express algorithmic problem-solving using sequence, selection and repetition structures. ● Modularise the algorithmic and operating capabilities of a program using functions, methods, subroutines or similar organising structures. ***Application Development*** ● Conduct a systematic requirements analysis to determine the basic facts used to organise the application of programming effort to solve a problem or reach a goal. ● Formalise and communicate requirements in a manner that is comprehensible for all stakeholders that will	***Programming*** ● Develop data storage strategies using primitive data types in a computer's volatile memory. ● Apply data transformations using arithmetic, assignment and transposition operators. ● Develop predicate expressions using relational and logical operators. ● Express algorithmic problem-solving using sequence, selection and repetition structures. ● Modularise the algorithmic and operating capabilities of a program using functions, methods, subroutines or similar organising structures. ● Select and utilise appropriate linear and non-linear data structures to maintain and manage sets of related data in non-volatile memory. ● Utilise Object-Oriented concepts in the organisation and structuring of programs for behaviour and concept management. ***Application Development*** ● Conduct a systematic requirements analysis to determine the basic facts used to organise the application of programming effort to

Knowledge Area	Certificate	Diploma	Bachelor's Degree
	● Develop the programming code implementation that realises the system architecture and design.	determine the success of the software system. ● Specify the software system architecture such that the principal components and dependencies of the system are visible and comprehensible for all involved in shaping the materials of design and construction. ● Identify the lateral components and libraries that the designed and developed system will depend on. ● Develop the programming code implementation that realises the system architecture and design. ● Test all developed programming code components to ensure fidelity, consistency and fit.	solve a problem or reach a goal. ● Formalise and communicate requirements in a manner that is comprehensible for all stakeholders that will determine the success of the software system. ● Specify the software system architecture such that the principal components and dependencies of the system are visible and comprehensible for all involved in shaping the materials of design and construction. ● Identify the lateral components and libraries that the designed and developed system will depend on. ● Develop the programming code implementation that realises the system architecture and design. ● Test all developed programming code components to ensure fidelity, consistency and fit. ● Maintain software throughout deployment and utilisation such that extant or new intentions and requirements are accommodated and the intended purpose will function. ● Adopt or adapt an appropriate software system process methodology such that people, resources, design requirements and other dynamic considerations allow for correctness and utility. ● Establish and maintain the appropriate dialogue

Knowledge Area	Certificate	Diploma	Bachelor's Degree
			among stakeholders that ensure a degree of communication and information transparency to maintain the viability of the software system.
Information System Management & Strategy	● Describe the concept of Information System Management and Strategy for an effective information system organisation. ● Explain an appropriate information system strategy for an organisation.	● Apply professional managerial skills to design and manage an effective information system organisation. ● Ensure operational efficiency and effectiveness in the service delivery of organisational information. ● Manage the information resources in coordination with line management. ● Create and manage the oversight mechanisms by which an organisation evaluates, directs and monitors organisational information technology – managing decision rights and organisational information technology decision-making practices.	● Apply professional managerial skills to design and manage an effective information system organisation. ● Ensure operational efficiency and effectiveness in the service delivery of organisational information. ● Manage the information resources in coordination with line management. ● Create and manage the oversight mechanisms by which an organisation evaluates, directs and monitors organisational information technology – managing decision rights and organisational information technology decision-making practices. ● Implement strategic plans that have been created for the delivery and use of organisational information systems. ● Ensure organisational information systems comply with policies, applicable laws and regulations. ● Manage organisational risk and develop risk mitigation plans. ● Create information technology procurement policies and understand and negotiate information technology contracts. ● Develop plans for workforce development,

Knowledge Area	Certificate	Diploma	Bachelor's Degree
			training, talent acquisition and employee retention. ● Apply leading service management frameworks, such as Information Technology Infrastructure Library (ITIL) and Capability Maturity Model Integration (CMMI). ● Identify commonly used governance frameworks, such as Control Objectives for Information and Related Technology (COBIT) and The Open Group Architecture Framework (TOGAF), to align information systems with organisational requirements.
Ethics, Sustainability, Use and Implications for Society	-	-	● Demonstrate ethical behaviour during data collection. ● Identify the moral issues that surround the storage and usage of data. ● Examine ethical philosophies and their practical application. ● Evaluate ethical codes of practice and their implications for society. ● Identify aspects of sustainability and adaptive systems and data. ● Categorise ethical stakeholders and their importance to Information Systems. ● Investigate sustainable processes, actions and performance to support organisations. ● Investigate sustainable processes, actions and performance to support an individual. ● Investigate sustainable processes, actions and

Knowledge Area	Certificate	Diploma	Bachelor's Degree
			performance to support society at large.
Information System Project Management	● Explain basic project management concepts and terms. ● Apply integration management tools, techniques and processes in information system projects.	● Explain basic project management concepts and terms. ● Use integration management tools, techniques and processes. ● Use scope management tools, techniques and processes. ● Develop estimates and time tracking using appropriate tools, techniques and processes. ● Develop estimates and cost tracking using appropriate tools, techniques and processes.	● Explain basic project management concepts and terms. ● Use integration management tools, techniques and processes. ● Use scope management tools, techniques and processes. ● Develop estimates and time tracking using appropriate tools, techniques and processes. ● Develop estimates and cost tracking using appropriate tools, techniques and processes. ● Utilise the change control process to maintain and control quality. ● Implement human resource management tools, techniques and processes. ● Define and implement a communication management plan. ● Predict and manage project risk using tools, techniques and processes. ● Define and explain procurement management. ● Identify and manage stakeholders within the phases of a project. ● Utilise tools, techniques and processes to manage project performance. ● Apply agile project management principles and methods in practice. ● Apply the Scrum development process. ● Select an appropriate project management

Knowledge Area	Certificate	Diploma	Bachelor's Degree
			methodology based on project characteristics.

- **COMPUTER SCIENCE**
  The body of knowledge for the Computer Science discipline and corresponding detail competencies are listed below. For more information, refer to "CS 2013: Curriculum Guidelines for Undergraduate Degree Programs in Computer Science".

Knowledge Area	Certificate	Diploma	Bachelor's Degree
Algorithms and Complexity	-	● Present to a group of peers the data characteristics of conditions or assumptions that can lead to different behaviours of specific algorithms for runtime measures. ● Use recurrence relations to determine the time complexity of recursively defined algorithms by solving elementary recurrence relations, and present the results to a group of scholars. ● Determine an appropriate algorithmic approach and use appropriate techniques (e.g., greedy approach and divide-and-conquer algorithm) to solve a routine problem.	● Present to a group of peers the data characteristics of conditions or assumptions that can lead to different behaviours of specific algorithms and from the analysis, illustrate empirical studies to validate hypotheses about runtime measures. ● Illustrate informally the time and space complexity of algorithms and use big-O notation formally to show asymptotic upper bounds and expected case bounds on time and space complexity, respectively. ● Use recurrence relations to determine the time complexity of recursively defined algorithms by solving elementary recurrence relations, and present the results to a group of scholars. ● Determine an appropriate algorithmic approach to an industry problem and use appropriate techniques (e.g., greedy approach, divide-and-conquer algorithm, recursive backtracking, dynamic programming and heuristic approach) that consider the trade-offs between the

Knowledge Area	Certificate	Diploma	Bachelor's Degree
			brute force to solve a problem. ● Implement basic numerical algorithm methods (e.g., search algorithms, common quadratic and O(N log N) sorting algorithms, fundamental graph algorithms and string-matching algorithms) to solve an industry problem and select the appropriate algorithm for a particular context. ● Design a deterministic finite state machine for a local engineering firm that accepts a specified language and generates a regular expression to represent the language.
Architecture and Organization	● Explain the relationships between hardware components and the subsystems in a computer system. ● Explain the differences between data representations – signed numbers, fixed and floating numbers and characters. ● Use simulation tools for the capture and simulation of a simple computer design.	● Explain the relationships between hardware components and the subsystems in a computer system. ● Use simulation tools for the capture, synthesis and simulation to evaluate simple building blocks of a simple computer design. ● Evaluate the timing diagram modelling of a simple processor implemented at the logic circuit level and develop a report expressing the findings. ● Write a simple program at the assembly / machine level.	● Use simulation tools for the capture, synthesis and simulation to evaluate simple building blocks of a simple computer design for a local engineering company. ● Evaluate the timing diagram modelling of a simple processor implemented at the logic circuit level and develop a report expressing the findings. ● Write a simple program at the assembly / machine level for string processing and manipulation and for converting numerical data into hexadecimal form. ● Implement a fundamental high-level construct in both machine and assembly languages and present the results to a group of peers. ● Calculate the average memory access time under a variety of cache and memory configurations and

Knowledge Area	Certificate	Diploma	Bachelor's Degree
			develop a short report of the findings.
Computational Science	-	-	● Create a simple, formal mathematical model of a real-world situation and use that model in a simulation for a local technology company.
Discrete Structures	-	● Present to a peer group some practical examples of an appropriate set, function or relation model, and interpret the associated operations and terminology in context. ● Use symbolic propositional and predicate logic to model a simple problem by applying formal methods (e.g., calculating the validity of formulae and computing normal forms to the symbolic logic). ● Apply rules of inference to construct proofs and present the results to a peer group, using appropriate proofs or logical reasoning to solve a strategic problem.	● Present to a peer group some practical examples of an appropriate set, function or relation model, and interpret the associated operations and terminology in context. ● Use symbolic propositional and predicate logic to model a real-life industry application by applying formal methods (e.g., calculating the validity of formulae and computing normal forms to the symbolic logic). ● Apply rules of inference to construct proofs and present results to a group of professionals, using appropriate proofs or logical reasoning to solve a strategic problem. ● Map real-world applications to appropriate counting formalisms and apply basic counting theories (e.g., counting arguments, the pigeonhole principle, modular arithmetic, as well as compute permutations and combinations of a set) to solve an industry problem. ● Analyse an industry problem to determine underlying recurrence relations and present the solution to professionals by using a variety of basic recurrence relations.

Knowledge Area	Certificate	Diploma	Bachelor's Degree
			● Model a real-world problem using appropriate graphing strategies (e.g., trees, traversal methods for graphs and trees, and spanning trees of a graph) and determine whether two graph approaches are isomorphic. ● Calculate different probabilities of dependent or independent events and expectations of random variables to solve a problem and present to a group of peers the ways to compute the variance for a given probability distribution.
Graphics and Visualisation	-	-	● Design and develop a user interface that incorporates visual and audio techniques used for a local organisation using a standard Application Programming Interface (API).
Human-Computer Interaction	● Describe the user interface design concept. ● Apply interactive techniques in an application with related tools.	● Design an interactive application, applying a user-centred design cycle with related tools and techniques (modes, navigation, visual design) to optimise usability and user experience. ● Analyse and evaluate a user interface, considering the context of use, stakeholder needs, state-of-the-art response interaction times, and design modalities taking into account universal access, inclusiveness, assistive technologies and culture-sensitive design. ● Design and develop an interactive application	● Design an interactive application, applying a user-centred design cycle with related tools and techniques (modes, navigation, visual design) to optimise usability and user experience within a corporate environment. ● Analyse and evaluate a user interface, considering the context of use, stakeholder needs, state-of-the-art response interaction times, and design modalities taking into account universal access, inclusiveness, assistive technologies and culture-sensitive design. ● Design and develop an interactive application for a local charity, applying a user-centred design cycle

Knowledge Area	Certificate	Diploma	Bachelor's Degree
		for a local charity, applying a user-centred design cycle with related vocabulary, tools and techniques that optimise usability and user experience.	with related vocabulary, tools and techniques that optimise usability and user experience. ● Create and conduct a simple usability test to analyse and evaluate a user interface, considering the context of use, universal access and cultural-sensitive design. ● Create a simple application, together with help and documentation, that supports a graphical user interface for an enterprise, and conduct a quantitative evaluation and report the results.
Information Assurance and Security	-	-	● Write the correct input validation code for a cybersecurity company after classifying common input validation errors. ● Demonstrate to a group of security professionals some ways to prevent a race condition from occurring and ways to handle exceptions.
Information Management	-	-	● Contrast information with data and knowledge and describe to a group of professionals the advantages and disadvantages of centralised data control. ● Demonstrate to a group of peers a declarative query language to elicit information from a database. ● Contrast appropriate data models, including internal structures, for different types of data, and present an application to a group of professionals for the use of modelling concepts and notation of the relational data model.

Knowledge Area	Certificate	Diploma	Bachelor's Degree
Intelligent Systems	-	● Determine the characteristics of a given problem that an intelligent system must solve and present the results to a project team. ● Implement an appropriate uninformed or informed simple search algorithm for decision-making. ● Apply an intelligent system technique(s) to solve a simple real-world problem.	● Determine the characteristics of a given problem that an intelligent system must solve and present the results to a project team. ● Formulate an industry problem specified in a natural language (e.g., English) as a constraint satisfaction problem and implement it using an appropriate technique (e.g., chronological backtracking algorithm and stochastic local search). ● Implement an appropriate uninformed or informed search algorithm for an industry problem by characterising the time and space complexities of an informed algorithm or designing the necessary heuristic evaluation function for an uninformed search algorithm to guarantee an optimal solution, respectively. ● Translate a natural language (e.g., English) sentence for a corporate query system into a predicate logic statement by converting a logic statement into clause form and applying resolution to a set of logic statements to answer a query. ● Make a probabilistic inference in a real-world industry problem using Bayes' theorem to determine the probability of a hypothesis with given evidence.
Networking and Communication	-	● Design and develop simple network programming.	● Design and develop for a corporate customer a simple client-server socket-based application.

Knowledge Area	Certificate	Diploma	Bachelor's Degree
		● Design and implement a simple reliable protocol by considering factors that affect the network's performance.	● Design and implement a simple reliable protocol for an industry network by considering factors that affect the network's performance. ● Contrast fixed and dynamic allocation techniques, as well as current approaches to congestion and present the results to company executives.
Operating Systems	-	-	● Apply knowledge of computing theory and mathematics to solve problems and present comprehensively the results and methods of the solution for either professional or non-professional audiences. ● Implement software solutions within system constraints of a target system by considering its abilities and constraints, and document and explain the implementation to both technical and non-technical audiences. ● Predict the modelling of systems under random events using knowledge of probability and expectation and inform users of its potential modelling. ● Assess the security of a system using the knowledge of confidentiality, availability and integrity with an understanding of risks, threats, vulnerabilities and attack vectors, and relate its societal and ethical impact to the system's constituents.

Knowledge Area	Certificate	Diploma	Bachelor's Degree
Platform-based Development	-	● Design for a client a responsive web application utilising a web framework and presentation technologies in support of a diverse online community. ● Develop for a company a mobile app that is usable, efficient and secure on more than one device.	● Design for a client a responsive web application utilising a web framework and presentation technologies in support of a diverse online community. ● Develop for a company a mobile app that is usable, efficient and secure on more than one device. ● Simulate for a company an industry platform. ● Develop and implement programming tasks via platform-specific APIs and present the results to a group of peers. ● Present the analysis of a mobile industrial system and illustrate correct security vulnerabilities.
Parallel and Distributed Computing	-	● Design a scalable parallel computing algorithm. ● Write a program for appropriate parallel and distributed computing applications.	● Design a scalable parallel algorithm for a computer firm by applying task-based decomposition or data-parallel decomposition. ● Write a program for a client that correctly terminates when all concurrent tasks terminate by considering actors and / or reactive processes, deadlocks and properly synchronised queues. ● Write a test program for a company that reveals a concurrent programming error (e.g., missing an update when two activities both try to increment a variable). ● Present computational results of the work and span in a program by identifying independent tasks that may be parallelised and determining the critical path for a parallel execution diagram.

Knowledge Area	Certificate	Diploma	Bachelor's Degree
			● Implement a parallel divide-and-conquer (and / or graph algorithm) for a client by mapping and reducing operations for the real industry problem, and empirically measure its performance relative to its sequential analogue.
Programming Languages	● Explain the behaviour of simple programs involving the fundamental programming construct. ● Compare various problem-solving tools in the problem-solving process for computers. ● Revise short programs that use standard conditional and iterative control structures and functions.	● Write event handlers for a web developer for use in reactive systems, such as GUIs. ● Demonstrate program pieces (such as functions, classes and methods) that use generic or compound types, including for collections to write programs. ● Write a program for a client to process a representation of code that illustrates the incorporation of an interpreter, an expression optimiser and a documentation generator.	● Present the design and implementation of a class that considers object-oriented encapsulation mechanisms (e.g., class hierarchies, interfaces and private members). ● Produce a brief report on the implementation of a basic algorithm that considers control flow in a program using dynamic dispatch that avoids assigning to a mutable state (or considering reference equality) for two different languages. ● Present the implementation of a useful function that takes and returns other functions considering variables and lexical scope in a program as well as functional encapsulation mechanisms. ● Use iterators and other operations on aggregates (including operations that take functions as arguments) in two programming languages and present to a group of professionals some ways of selecting the most natural idioms for each language. ● Contrast and present to peers: (1) the procedural / functional approach (defining a function for each operation with the function body providing a

Knowledge Area	Certificate	Diploma	Bachelor's Degree
			case for each data variant) and (2) the object-oriented approach (defining a class for each data variant with the class definition providing a method for each operation). ● Write event handlers for a web developer for use in reactive systems, such as GUIs. ● Demonstrate program pieces (such as functions, classes and methods) that use generic or compound types, including for collections to write programs. ● Write for a client a program to process a representation of code that illustrates the incorporation of an interpreter, an expression optimiser and a documentation generator. ● Use type-error messages, memory leaks and dangling-pointer to debug a program for an engineering firm.
Software Development Fundamentals	● Identify key concepts in computing and the typical activities involved in creating programmes. ● Explain computation thinking techniques for problem decomposition. ● Apply project management methodologies, such as testing, debugging and releasing in program development.	● Create an appropriate algorithm to illustrate iterative and recursive functions, as well as divide-and-conquer techniques and use a programming language to implement, test and debug the algorithm for solving a simple problem. ● Design, implement, test and debug a program that uses fundamental programming constructs, including basic computation, simple and file input/output (I/O), standard conditional and iterative structures,	● Create an appropriate algorithm to illustrate iterative and recursive functions, as well as divide-and-conquer techniques and use a programming language to implement, test and debug the algorithm for solving a simple industry problem. ● Decompose for a client a program that identifies the data components and behaviours of multiple abstract data types, and implement a coherent abstract data type with loose coupling between components and behaviours.

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		the definition of functions and parameter passing.	● Design, implement, test and debug an industry program that uses fundamental programming constructs, including basic computation, simple and file I/O, standard conditional and iterative structures, the definition of functions and parameter passing. ● Present the costs and benefits of dynamic and static data structure implementations, choosing the appropriate data structure for modelling a given engineering problem. ● Apply consistent documentation and program style standards for a software engineering company that contribute to the readability and maintainability of software, conducting a personal and small-team code review on a program component using a provided checklist. ● Demonstrate common coding errors, constructing and debugging programs using the standard libraries available with a chosen programming language. ● Refactor an industry program by identifying opportunities to apply procedural abstraction.
Software Engineering	-	-	● Conduct a review of a set of software requirements for a local project, distinguishing between functional and non-functional requirements, and evaluate the extent to which the set exhibits the characteristics of good requirements.

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			● Present to a client the design of a simple software system using a modelling notation (such as Unified Modeling Language [UML]), including an explanation of how the design incorporates system design principles.
Systems Fundamentals	-	● Design a simple sequential problem and a parallel version of the same problem using fundamental building blocks of logic design and use appropriate tools to evaluate the design for an organisation. ● Develop for an organisation a program that incorporates error detection and recovery with appropriate tools for program tracing and debugging. ● Design for an organisation a simple parallel program that manages shared resources through synchronisation primitives, and use tools to evaluate program performance.	● Design a simple sequential problem and a parallel version of the same problem using fundamental building blocks of logic design, use appropriate tools to evaluate the design for a commercial organisation and evaluate both problem versions. ● Develop for a local organisation a program that incorporated error detection and recovery with appropriate tools for program tracing and debugging. ● Design for a corporation a simple parallel program that manages shared resources through synchronisation primitives, and use tools to evaluate program performance. ● Design and conduct a performance-oriented, pattern recognition experiment incorporating state machine descriptors and simple schedule algorithms for exploiting redundant information and data correction that is usable for a local engineering company, and use appropriate tools to measure program performance. ● Calculate average memory access time and describe the trade-offs in

Knowledge Area	Certificate	Diploma	Bachelor's Degree
			memory hierarchy performance in terms of capacity, miss / hit rate and access time for a local engineering company. ● Measure the performance of two application instances running on separate virtual machines at a local engineering company and determine the effect of performance isolation.
Social Issues and Professional Practice	-	-	● Perform a system analysis for a local organisation and present the results to the organisation in a non-technical way. ● Integrate interdisciplinary knowledge to develop a program for a local organization. ● Document industry trends, innovations and new technologies and produce a report to influence a targeted workspace. ● Present to a group of professionals an innovative computer system by using audience-specific language and examples to illustrate the group's needs. ● Produce a document that addresses the effect of societal change due to technology and is helpful to others. ● Adopt processes to track customer requests, needs and satisfaction. ● Compare different error detection and correction methods for their data overhead, implementation complexity and relative execution time for encoding, detecting and correcting errors, and ensure that any error does not affect humans adversely.

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- **SOFTWARE ENGINEERING**

  The body of knowledge for the Software Engineering discipline and corresponding detail competencies are listed below. For more information, refer to “SE 2014: Curriculum Guidelines for Undergraduate Degree Programs in Software Engineering”.

Knowledge Area	Certificate	Diploma	Bachelor’s Degree
Software Requirements	● Explain the software requirements concept. ● Identify the type of requirements, such as functional and non-functional requirements. ● Describe software requirement processes (elicitation, specification, verification / validation and management) for a simple project.	● Identify and document software requirements by applying a known requirements elicitation technique in work sessions with stakeholders, using facilitative skills as a contributing member of a requirements team. ● Analyse software requirements for consistency, completeness and feasibility, and recommend improved requirements documentation as a contributing member of a requirements team. ● Specify software requirements using standard specification formats and languages that have been selected for the project and be able to describe the requirements in an understandable way to non-experts, such as end-users, other stakeholders and administrative managers, as contributing members of a requirements team.	● Identify and document software requirements by applying a known requirements elicitation technique in work sessions with stakeholders, using facilitative skills as a contributing member of a requirements team. ● Analyse software requirements for consistency, completeness and feasibility, and recommend improved requirements documentation as a contributing member of a requirements team. ● Specify software requirements using standard specification formats and languages that have been selected for the project and be able to describe the requirements in an understandable way to non-experts, such as end-users, other stakeholders or administrative managers, as contributing members of a requirements team. ● Verify and validate the requirements using standard techniques, including inspection, modelling, prototyping and test case development, as a contributing member of a requirements team.

Knowledge Area	Certificate	Diploma	Bachelor's Degree
			● Follow process and product management procedures that have been identified for the project as a contributing member of the requirements engineering team.
Software Design	● Describe software design processes, such as input, process and output. ● Identify components of software design, such as architecture, interface, component, algorithm and database.	● Present to business decision-makers architecturally significant requirements from a software requirements specification document. ● Evaluate and compare trade-offs from alternative design possibilities for satisfying functional and non-functional requirements and write a brief proposal summarising key conclusions for a client. ● Produce a high-level design of specific subsystems by considering architectural and design patterns which is presentable to non-computing audiences. ● Produce detailed designs for a client for specific subsystem high-level designs by using design principles and cross-cutting aspects to satisfy functional and non-functional requirements.	● Present to business decision-makers architecturally significant requirements from a software requirements specification document. ● Evaluate and compare trade-offs from alternative design possibilities for satisfying functional and non-functional requirements and write a brief proposal summarising key conclusions for a client. ● Produce a high-level design of specific subsystems by considering architectural and design patterns which is presentable to non-computing audiences. ● Produce detailed designs for a client for specific subsystem high-level designs by using design principles and cross-cutting aspects to satisfy functional and non-functional requirements. ● Evaluate software testing consideration of quality attributes in the design of subsystems and modules for a developer / manufacturer. ● Create software design documents that communicate effectively to software design clients, such as analysts,

Knowledge Area	Certificate	Diploma	Bachelor's Degree
			implementers, test planners and maintainers.
Software Construction	-	-	● Design and implement an API using an object-oriented language and extended libraries, including parameterisation and generics on a small project. ● Evaluate a software system against modern software practices, such as defensive programming, error and exception handling, and accepted fault tolerances, in a runtime mode that considers state-based table-driven constructions on a large project as a member of a project team. ● Develop a distributed cloud-based system that incorporates grammar-based inputs and concurrency primitives for a medium-sized project and then conduct a performance analysis to fine-tune the system as a member of a project team.
Software Testing	● Describe the type of software testing. ● Identify software testing life cycle from analysis of requirements until test closure phase. ● Apply the concept of software testing to measure the usability of the software.	● Conduct a test utilising appropriate testing tools focused on desirable quality attributes specified by the quality control team and the client. ● Plan and conduct process to design test cases for an organisation using both clear- and black-box techniques to measure quality metrics in terms of	● Perform an integrative test and analysis of software components by using black-box and use case techniques in collaboration with clients. ● Conduct for a client a regressive test of software components that considers operational profiles and quality attributes specific to an application following empirical data

Knowledge Area	Certificate	Diploma	Bachelor's Degree
		coverage and performance.	and the intended usages. ● Conduct a test utilising appropriate testing tools focused on desirable quality attributes specified by the quality control team and the client. ● Plan and conduct for an organisation a process to design test cases using both clear- and black-box techniques to measure quality metrics in terms of coverage and performance.
Software Sustainment	-	-	● Describe the criteria for transition into a sustainment status and assist in identifying applicable systems and software operational standards. ● Relate to the needs of operational support personnel for documentation and training and help develop software transition documentation and operational support training materials. ● Help in determining the impacts of software changes on the operational environment. ● Describe the elements of software support activities, such as configuration management, operational software assurance, help desk activities, operational data analysis and software retirement. ● Perform software support activities and interact effectively with

Knowledge Area	Certificate	Diploma	Bachelor's Degree
			other software support personnel. ● Assist in implementing software maintenance processes and plans and make changes to the software to implement maintenance needs and requests.
Software Process and Life Cycle	● Describe software processes. ● Describe the software lifecycle.	● Engage with a team to translate a software development process into individual areas of responsibility. ● Justify software lifecycle process improvements based on team capacity, project progress data and quality analysis as part of a software development team's retrospective activities.	● Engage with a team to translate a software development process into individual areas of responsibility. ● Commit to and perform tasks related to assigned or agreed-upon areas of responsibility. ● Propose and justify software lifecycle process improvements based on team capacity, project progress data and quality analysis as part of a software development team's retrospective activities.
Software Systems Engineering	-	-	● Provide a description of system engineering concepts and activities to identify problems or opportunities, explore alternatives, create models and test them. ● Develop the big picture of a system in its context and environment to simplify and improve system architectures for supporting system designers. ● Develop interfaces that interact with other subsystems. Use information hiding to isolate the contents and collaborations within subsystems so that clients of the subsystem

Knowledge Area	Certificate	Diploma	Bachelor's Degree
			need not be aware of the internal design of subsystems. ● Work effectively with engineers and developers from other disciplines to ensure effective interaction.
Software Quality	● Describe the software quality process. ● Identify quality characteristics.	● Distinguish quality attributes that are discernible at run-time (performance, security, availability, functionality and usability) from those not discernible at run-time (modifiability, portability, reusability, integrability and testability), and those related to the intrinsic qualities of architecture and detailed design (conceptual integrity, correctness and completeness). ● Design, coordinate and execute within a project team the software quality assurance plans for small software subsystems and modules, considering how quality attributes are discernible. Correspondingly, measure, document and communicate the results appropriately.	● Distinguish quality attributes that are discernible at run-time (performance, security, availability, functionality and usability) from those not discernible at run-time (modifiability, portability, reusability, integrability and testability), and those related to the intrinsic qualities of architecture and detailed design (conceptual integrity, correctness and completeness). ● Design, coordinate, and execute within a project team the software quality assurance plans for small software subsystems and modules, considering how quality attributes are discernible. Correspondingly, measure, document and communicate the results appropriately. ● Perform peer code reviews for evaluating quality attributes that are not discernible at run-time. ● Explain the statistical nature of quality evaluation when performed on software execution, develop, deploy and implement approaches to collect statistical usage and testing outcome data,

Knowledge Area	Certificate	Diploma	Bachelor's Degree
			and compute and analyse statistics on outcome data. ● Interact with external entities, including clients, users and auditing agencies, in conveying quality goals for processes and products.
Software Security	● Describe software security processes, such as the concept of secure SDLC, framework and checkpoints. ● Identify software security activities.	● Apply the project's selected security lifecycle model (e.g., Microsoft SDL) as a contributing member of a project team. ● Identify security requirements by applying the selected security requirements method as a contributing member of a software project team.	● Apply the project's selected security lifecycle model (e.g., Microsoft SDL) as a contributing member of a project team. ● Identify security requirements by applying the selected security requirements method as a contributing member of a software project team. ● Incorporate security requirements into architecture, high-level and detailed design as a contributing member of a software project team. ● Develop software using secure coding standards. ● Execute test cases that are specific to security. ● Adhere to the project's software development process as a contributing member of a software project team. ● Develop software that supports the project's quality goals and adheres to quality requirements.
Software Safety	● Describe the concept of software safety. ● Explain the software safety processes.	● Describe the principal activities with the development of software systems, which involve safety	● Describe the principal activities with the development of software systems, which involve safety concerns

Knowledge Area	Certificate	Diploma	Bachelor's Degree
		concerns (activities related to requirements, design, construction and quality).	(activities related to requirements, design, construction and quality). ● Create and verify preliminary hazard lists, perform hazard and risk analyses, and identify safety requirements. ● Implement and verify design solutions, using safe design and coding practices, to assure that the hazards are mitigated and the safety requirements are met. ● Be aware of the consequences of the development of unsafe software, that is, the negative effect on those who use or receive services from the software.
Software Measurement	-	-	● Develop and implement plans for the measurement of software processes and work products using appropriate methods, tools and abilities.
Project Management	● Explain the principal elements of project management.	● Explain the principal elements of management for a small project team. ● Assist in the managerial aspects of a small project team, including software estimation, project planning, tracking, staffing, resource allocation and risk management.	● Explain the principal elements of management for a small project team. ● Assist in the managerial aspects of a small project team, including software estimation, project planning, tracking, staffing, resource allocation and risk management. ● Develop and implement plans for the measurement of software processes and work products using

Knowledge Area	Certificate	Diploma	Bachelor's Degree
			appropriate methods and tools. ● Work with other team members in project management activities effectively.
Behavioural Attributes	● Engage with team members to collaborate in solving a problem. ● Work done towards team effort is accomplished on time; it complies with the role played in the team.	● Engage with team members to collaborate in solving a problem, effectively applying oral and / or written communication skills. ● Work done towards team effort is accomplished on time; it complies with the role played in the team, uses established quality procedures and advances the team effort. ● Assist in the analysis and presentation of a complex problem, considering the needs of stakeholders from diverse cultures, needs and / or geographic locations. Help in developing a solution for the problem and presenting it to stakeholders, explaining the economic, social and / or environmental impact of the proposed solution. Identify areas of uncertainty or ambiguity and explain how these have been managed.	● Engage with team members to collaborate in solving a problem, effectively applying oral and / or written communication skills. ● Work done towards team effort is accomplished on time; it complies with the role played in the team, uses established quality procedures and advances the team effort. ● Assist in the analysis and presentation of a complex problem, considering the needs of stakeholders from diverse cultures, needs and / or geographic locations. Help in developing a solution for the problem and presenting it to stakeholders, explaining the economic, social, and / or environmental impact of the proposed solution. Identify areas of uncertainty or ambiguity and explain how these have been managed. ● Analyse software employment contracts from various social and legal perspectives, ensuring that the final product conforms to professional and ethical expectations, and follows standard licensing practices.

Knowledge Area	Certificate	Diploma	Bachelor's Degree
			● Locate and make sense of learning resources, and use them to expand knowledge, skills and dispositions. Reflect upon one's learning and how it provides a foundation for future growth.

- **DATA SCIENCE**

The key competencies of Data Science are interdisciplinary in nature with a strong focus on mathematics and statistics. The core computing discipline-specific KAs for Data Science listed below need to be augmented with competencies in calculus, probability theory, elementary statistics, advanced topics in statistics and linear algebra among others. A complete curriculum would also include at least one domain context for the application of Data Science concepts and methods.

The body of knowledge for the Data Science discipline and corresponding detail competencies are listed below. For more information, refer to "CCDS 2021: Computing Competencies for Undergraduate Data Science Curricula".

Knowledge Area	Bachelor's Degree
Discrete Structure (DS)	● Present to a peer group some practical examples of an appropriate set, function or relation model, and interpret the associated operations and terminology in context. ● Use symbolic propositional and predicate logic to model a real-life industry application by applying formal methods (e.g., calculating the validity of formulae and computing normal forms to the symbolic logic). ● Apply rules of inference to construct proofs and present results to a group of professionals, using appropriate proofs or logical reasoning to solve a strategic problem. ● Map real-world applications to appropriate counting formalisms and apply basic counting theories (e.g., counting arguments, the pigeonhole principle, modular arithmetic, as well as compute permutations and combinations of a set) to solve an industry problem. ● Analyse an industry problem to determine underlying recurrence relations and present the solution to professionals by using a variety of basic recurrence relations. ● Model a real-world problem using appropriate graphing strategies (e.g., trees, traversal methods for graphs and trees, and spanning trees of a graph) and determine whether two graph approaches are isomorphic. ● Calculate different probabilities of dependent or independent events and expectations of random variables to solve a problem and present to a group of peers the ways to compute the variance for a given probability distribution.

Knowledge Area	Bachelor's Degree
Analysis and Presentation (AP)	● Recognise the main strands of knowledge underpinning approaches to Analysis and Presentation. ● Summarise the skills and techniques (including tools) that can be employed in addressing each of the challenges of Analysis and Presentation to create efficient and effective interfaces. ● Apply a critical demeanour and also confidence and creativity regarding all aspects of the human-computer interface. ● Execute the selection of tools appropriate for the size of the data / Big Data to be rendered.
Artificial Intelligence (AI)	● Describe major areas of AI, as well as contexts in which AI methods may be applied overall and specifically in Data Science. ● Represent information in a logical formalism and apply relevant reasoning methods. ● Represent information in a probabilistic formalism and apply relevant reasoning methods. ● Be aware of the wide range of ethical considerations around AI systems, as well as mechanisms to mitigate problems.
Big Data Systems (BDS)	● Describe the main strands of knowledge needed to address Big Data applications, highlighting areas where collaboration is desirable. ● Provide familiarity with a range of skills that may be used in the implementation of Big Data applications. ● Instil confidence in dealing with the problems of Big Data.
Computing and Computer Fundamentals (CCF)	● Appreciate ways in which digital representations of data affect efficiency and precision. ● Recognise that there are different types of processors and configurations of them. ● Understand the trade-offs between expensive / fast memory and inexpensive / slower memory. ● Summarise the important role of an operating system and the ways in which it is both vulnerable to and can be protected from attack. ● Carry out the creation, organisation and protection of files. ● Understand at a high level how networks are organised and transmit information. ● Recognise the web as an application layer on the internet. ● Use the web to gather information and build useful applications. ● Understand that while compilers and interpreters are both translators of code, they have their respective benefits and limitations.
Data Acquisition, Management, and Governance (DG)	● Construct a data governance process according to the requirements of applications, including data preparation algorithms and steps. (Process Construction and Tuning) ● Write semantics rules for data governance, including information extraction, data integration and data cleaning. (Rules Definition) ● Develop scalable and efficient algorithms for data governance according to the requirements of applications (including data

Knowledge Area	Bachelor's Degree
	extraction, integration, sampling, reduction, data compression, transformation and cleaning algorithm. (Algorithm Development) ● Diagram the static and dynamic properties of data, changing mechanisms of data and similarity between data. (Property Description and Discovery) ● Develop policies and processes to ensure the privacy and security of data.
Data Mining (DM)	● Explain the range of techniques available for mining data, as well as the related algorithms and their suitability. ● Identify and use tools and techniques for mining data that may exist in various forms. ● Engender in students a high level of well-founded confidence in mining data.
Data Privacy, Security, Integrity, and Analysis for Security (DPSIA)	**Data Privacy** ● Justify the concept of privacy, including the societal definition of what constitutes personally private information and the trade-offs between individual privacy and security. ● Summarise the trade-offs between the rights to privacy by the individual and the needs of society. ● Evaluate common practices, technologies and tools that reduce the risk of data breaches and safeguard data privacy. ● Debate how organisations with international engagement must consider variances in privacy laws, regulations and standards across the jurisdictions in which they operate. This topic includes how law and technology intersect in the context of the judicial structures that are present – international, national and local – as organisations safeguard information systems from cyberattacks. **Data Security** ● Describe the purpose of cryptography and list ways it is used in data communications, as well as which cryptographic protocols, tools and techniques are appropriate for a given situation. ● Understand cipher (cypher), cryptanalysis, cryptographic algorithm and cryptology. ● Explain how public key infrastructure supports digital signing and encryption and discuss the limitations / vulnerabilities. ● Exhibit a mathematical understanding of encryption algorithms. ● Explain the difference between, and applications of, Symmetric and Asymmetric ciphers. ● Analyse threats to real-time applications that consume / produce critical data. ● Utilise attack vectors and attack tree concepts to model threats. ● Explain how data transmissions over a network or the web can be protected. **Data Integrity** ● Explain the differences between data integrity, data security and data privacy. ● Describe the main strands of knowledge needed to address data integrity.

Knowledge Area	Bachelor's Degree
	● Demonstrate the skills to apply commonly used methods to ensure data integrity. ● Perform confidently when dealing with security threats affecting data integrity. **Analysis for Security** ● Categorise different security-critical applications and understand various security telemetry data. ● Demonstrate in-depth knowledge and strong hands-on implementation skills in machine learning (ML) and statistical methods to improve security applications. ● Recognise when ML explainability and resiliency are necessary for a security application.
Machine Learning (ML)	● Recognise the breadth and utility of machine learning methods. ● Compare and contrast machine learning methods. ● Select appropriate (classes of) machine learning methods for specific problems. ● Use appropriate training and testing methodologies when deploying machine learning algorithms. ● Explain methods to mitigate the effects of overfitting and the curse of dimensionality in the context of machine learning algorithms. ● Identify an appropriate performance metric for evaluating machine learning algorithms / tools for a given problem. ● Recognise problems related to algorithmic and data bias, as well as privacy and integrity of data. ● Debate the possible effects – both positive and negative – of decisions arising from machine learning conclusions.
Professionalism (PR)	● Recognise the range of knowledge that underpins a professional approach to Data Science. ● Demonstrate the skills that underpin a current and ongoing professional approach to Data Science. ● Construct a set of dispositions that underpin a confident, effective and professional approach to all aspects of Data Science, as well as the wherewithal to maintain such an approach.
Programming, Data Structures, and Algorithms (PDA)	● Design an algorithm in a programming language to solve a well-defined problem. ● Write clear and correct code in a programming language that includes primitive data types, references, variables, expressions, assignments, I/O, control structures, functions and recursion. ● Use techniques of decomposition to modularise a program. ● Use standard libraries for a given programming language. ● Write appropriate database queries. ● Select appropriate data structures for a given problem. ● Select appropriate algorithms for a given problem. ● Discuss the importance of time and space complexity on the practical utility of an algorithm. ● Implement good documentation practices in programming.

Knowledge Area	Bachelor's Degree
Software Development and Maintenance (SDM)	● Implement a small software project that uses a defined coding standard. ● Test code by including security, unit testing, system testing, integration testing and interface usability.

For any programme that encompasses two PSs, HEPs are to refer to the Body of Knowledge (BOK) of both PSs. In terms of other components of standards, HEPs are to adopt whichever is higher.

The BOK mapping must factor in: the HEP's infrastructure and manpower, the unique selling point of the HEP, the programme level offered according to the MQF level and the mapping of the PLO proposed.

For detailed cybersecurity knowledge areas, kindly refer to the ACM Cybersecurity curricula.

APPENDIX 5

EXAMPLE OF NOMENCLATURE

Programme Structure / Level	Explanation	Example***
Certificate	Must be prefixed by Information Technology, Information System, Software Engineering or Computer Science disciplines. The programme structure for **Certificate** programmes shall not include specialisation.	● Certificate in Information Technology ● Certificate in Software Engineering ● Certificate in Networking **IS NOT ALLOWED** ● Certificate in Computer Science (Data Science) **IS NOT ALLOWED**
Diploma	Must be prefixed by Information Technology, Information System, Software Engineering or Computer Science disciplines. The programme structure for **Diploma** programmes shall not include specialisation.	● Diploma in Information Technology ● Diploma in Computer Science ● Diploma in Networking **IS NOT ALLOWED** ● Diploma in Computer Science (Data Science) **IS NOT ALLOWED**
Bachelor – Single Major	Must be prefixed by Information Technology, Information System, Software Engineering, Computer Science or Data Science disciplines. Programme that focuses only on one main area.	● Bachelor of Information Technology ● Bachelor of Information Systems ● Bachelor of Data Science ● Bachelor of Cybersecurity **IS NOT ALLOWED**
Bachelor – Major with Specialisation	Must be prefixed by Information Technology, Information System, Software Engineering, Computer Science or Data Science disciplines. A programme that has a **specialised field** that covers 25-30%* of the body of knowledge **for the area of specialisation**. This specialisation is indicated in the bracket.	● Bachelor of Computer Science (Mobile Application) ● Bachelor of Information Systems (Business Management) ● Bachelor of Software Engineering (Software Testing) ● Bachelor of Data Science (Artificial Intelligence) ● Bachelor of Computer Science (Cyber Security) ● Bachelor of Information Technology (Cyber Security) ● Bachelor of Computer Science (Software

Programme Structure / Level	Explanation	Example***
		Engineering) **IS NOT ALLOWED**
Bachelor – Major and Minor	Programme with a **minor** that includes 25-30%* of the body of knowledge **in another discipline****. The conjunction **'with'** is used in naming this type of programme where the major and minor disciplines are mentioned.	● Bachelor of Computer Science with Marketing ● Bachelor of Software Engineering with Entrepreneurship
Bachelor – Double Major	A double major programme should consist of an equal percentage (50%) of the body of knowledge from **two different disciplines**. The conjunction **'and'** is used in naming this type of programme where both disciplines are mentioned.	**Double Major (Same Discipline)** ● Bachelor of Information Systems and Data Science **Double Major (Different Discipline)** ● Bachelor of Information Systems and Marketing
Master's Degree by Coursework and Mixed Mode	**With Prefix** Must be prefixed by Information Technology, Information System, Software Engineering, Computer Science and Data Science disciplines. **Without Prefix** Nomenclatures for any specialisation in the computing areas should follow the following requirements: - Must have a rubric to reflect the knowledge area of the defined discipline/s. - The title of the research should reflect the defined discipline/s. - The supervisors and examiners must be from the defined discipline/s.	**With Prefix** ● Master of Computer Science ● Master of Data Science ● Master of Computer Science (Mobile Development) ● Master of Computer Science (Software Engineering) **IS NOT ALLOWED** **Without Prefix** ● Master of Cybersecurity ● Master of Mobile Application Development ● Master of Networking (Secure Programming) **IS NOT ALLOWED**
Master's Degree by Research	**With Prefix** Must be prefixed by Information Technology, Information System, Software Engineering, Computer Science and Data Science disciplines. **Without Prefix** Nomenclatures for general computing should follow the following requirements:	**With Prefix** ● Master of Computer Science ● Master of Software Engineering ● Master of Computer Science (Mobile Development) **IS NOT ALLOWED**

Programme Structure / Level	Explanation	Example***
	- Must have a rubric to reflect the knowledge area of the defined discipline/s. - The title of the research should reflect the defined discipline/s. - The supervisors and examiners must be from the defined discipline/s.	● Master of Computer Science (Software Engineering) **IS NOT ALLOWED** **Without Prefix** ● Master of Computing
Doctoral Degree by Mixed Mode	**With Prefix** Must be prefixed by Information Technology, Information System, Software Engineering, Computer Science and Data Science disciplines. **Without Prefix** Nomenclatures for general computing should follow the following requirements: - Must have a rubric to reflect the knowledge area of the defined discipline/s. - The title of the research should reflect the defined discipline/s. - The supervisors and examiners must be from the defined discipline/s. - The programme structure for doctoral by mixed mode programmes shall not include specialisation.	**With Prefix** ● Doctor of Software Engineering **Without Prefix** ● Doctor of Computing
Doctoral Degree by Research	**With Prefix** Must be prefixed by Information Technology, Information System, Software Engineering, Computer Science and Data Science disciplines. **Without Prefix** Nomenclatures for general computing should follow the following requirements: - Must have a rubric to reflect the knowledge area of the defined discipline/s.	**With Prefix** ● Doctor of Philosophy in Computer Science **Without Prefix** ● Doctor of Philosophy in Computing

Programme Structure / Level	Explanation	Example***
	- The title of the research should reflect the defined discipline/s. - The supervisors and examiners must be from the defined discipline/s.	

*Calculation of the percentage of major, specialisation and minor are based on credit hours.
**Discipline refers to the major field of the programme.
***Example given is for guidance only. The list is not exhaustive.

Notes:

- If the percentage of courses offered in the programme structure is less than 25% of the body of knowledge of the major discipline, it should not be stated in the programme nomenclature. However, it can be stated in the transcript. (Refer to the Guidelines on Nomenclature of the Malaysian Higher Education Programme for further details).

APPENDIX 6

AREA OF EMPLOYMENT

Computing graduates will find it essential or highly advantageous to have a prospective position (but not limited to) as listed below:

Computer Science
Computer Technician
Data Analyst
Data Engineer
Data Scientist
Database Administrator
Hardware Engineer
ICT application configurator
ICT Resilience Manager
ICT Sales Professionals
ICT Technician
Information Manager
Lecturer
Mobile Developer
Network Technician
Networking Engineer
Project Manager
Software Engineer
Software Manager
Software Tester
System Administrator
System Analysis and Design
System Developer
System Manager
User Experience Analyst
User Experience Engineer
Web Developer

GLOSSARY

1.	Conspectus	A critical review report submitted by a masters or doctoral candidate which includes and integrates creative works or artefacts as evidence of advanced knowledge and scholarship to address all aspects of masters or doctoral outcomes.
2.	Continuous Assessment	Assessment conducted on a continuous basis throughout the learning experience and includes formative and summative assessment opportunities. It is carried out at any of the predetermined points of the total learning experience. These consecutive assessment opportunities, which include a variety of assessment methods, have predetermined weightings and include the assessment of all the outcomes within the module.
3.	Core Ability / Social Skill and Social Value	Essential workplace skills or broad common abilities that cut across occupational and academic titles. They are broader skills that run through courses and are cross-functional to many disciplines and occupations. They enable learners to perform competencies and are learning tools supporting the NOSS requirements.
4.	Core Course	Required courses for all disciplines related to Computing programmes.
5.	Course	Components of a programme. The term ‘courses’ is used interchangeably with subjects, units or courses.
6.	Discipline Core of Knowledge Area	The core knowledge area for a specific area of computing.
7.	Dissertation	Documentation of the original research prepared and submitted by the candidate for the award of the

		degree for Master's programmes by research and mixed mode.
8.	Field Elective	Courses that fall under any Computing discipline.
9.	Final Assessment	The last activity students must complete in a course. A final assessment may be an exam, a culminating activity or a combination of the two. This task assesses students' knowledge of a subject and may be cumulative. A final assessment is similar in nature to a summative assessment, which includes end-of-unit tests, standardised testing and cumulative work, such as curating a portfolio over the duration of a course.
10.	Free Elective	Non-computing courses.
11.	Industrial Exposure	A student's experience in an organisation through field visits in the industry that is appropriate to their field. This exercise does not carry any credit values.
12.	Industrial Training / Industrial Attachment	A period of time within the programme when students are required to be placed in the industry to experience a real working environment.
13.	Interview	An interview is designed to assess a student's academic potential. Decisions are generally based on the student's ability to think independently and to engage with new ideas.
14.	Learning Outcome	Statements on what a learner should know, understand and do upon the completion of a period of study.
15.	Open and Distance Learning (ODL)	The provision of flexible educational opportunities in terms of access and multiple modes of knowledge acquisition.

16.	Programme	An arrangement of courses that are structured for a specified duration with a specified learning volume to achieve the stated learning outcomes. This usually leads to an award of a qualification.
17.	Programme Educational Objective	Broad statements that describe the career and professional accomplishments that the programme is preparing graduates to achieve after they have graduated.
18.	Project Paper	An extended piece of work involving inquiry-based activities. The project may be big or small and undertaken individually or in groups.
19.	Quality Assurance	Comprises planned and systematic actions (policies, strategies, attitudes, procedures and activities) to provide an adequate demonstration that quality is being achieved, maintained and enhanced, and meets the specified standards of teaching, scholarship and research, as well as student-learning experience.
20.	Related Field	Same (within) fields of study.
21.	Relevant Field	Different fields of study.
22.	Rigorous Internal Assessment	A process to evaluate the suitability of an applicant for the programme with the purpose that covers the following criteria: Demonstration of candidates' academic and personal development experience in the relevant fields for the required basic skills and acquired knowledge of the programme. The aptitude of the candidate suited towards the provided programme through these recommended measured tests (list is not limited to): Interview or

	formulated assessments for Verbal Reasoning, Diagrammatic Reasoning, Situational Judgement, E-tray Exercise, Error Checking, Personality Tests, Cognitive Ability, Spatial Awareness. These assessments can be done via conventional meet or online (both synchronous or asynchronous manners) For postgraduate level (master's and doctoral), internal rigorous assessments are recommended to include research proposal as a part of the process. The assessment of the proposal would require the articulation of the proposition or question underpinning and guiding the academic inquiry with clear structured arguments in support of the proposition.
23. Thesis	Documentation of the original research prepared and submitted by the candidate for the award of the degree for doctoral programmes by research and mixed mode.
24. Viva Voce	An oral examination of students' communication skills and knowledge of relevant facts from their thesis or dissertation.