BW13 Foundation Degree in Motorsport Engineering

Your quality handbook

Academic Year: 2021-2022

Full and Part-Time
University Centre Somerset

Course Leader: Josh Smith
Liaison Manager: Stephen Samuel

Professional Body Accreditation: Partial IET and IMECHE
Exit Awards Available: CertHE upon successful completion of 120 credits

Contents

Introduction

Welcome to your student quality handbook,

This handbook outlines the structure of your course including details of the modules you will be studying, how the modules are taught. The assessment strategies for each assignment and the learning outcomes (what you will gain).

The quality handbook ties in with your student handbook and they should be saved together and referred to whenever you have a question surrounding your course.

The Mapping Table below helps you to identify the learning outcomes of each module over your 2 year Foundation Degree course.

YEAR 1	ENGA4007 Work-based Assessment	ENGA4011 CAD CAM and Data Acquisition	ENGA4009 Mathematics I	ENGA4010 Engineering Science	ENGA4008 Composites and Materials Tech	ENGA4012 Engine Technology	YEAR 2	ENGA5017 Project	ENGA5010 Vehicle Dynamics and Performance Eng	ENGA5012 Computer Aided Engineering	ENGA5011 Vehicle Electronics & Microprocessor	ENGA5015 Mathematics II	ENGA5016 Motorsport Fluid Dynamics	ENGA5013 Manufacturing I	ENGA5014 Manufacturing II
1 Academic Literacy															
Understand and use the scientific principles which underpin the design and operation of mechanical systems.		1	1	1	1	1			1	1	1	1	1		
Understand the day to day running of a professional team in both management and technical areas.	1					1		1	1	1				1	1
Have a good understanding of modern systems within a vehicle and advanced technology integration and development.		1		1	1	1		1	1		1		1	1	

Apply appropriate mathematical principles to problems in Motorsport Engineering.			1	1		1				1		1	1		
Design and implement management structures within an organisation.	1														1
2 Research Literacy															
Design, manufacture and test components to develop and enhance a vehicle system.	1	1			1			1	1	1			1		
Be able to maintain and manage a major piece of research work linked to industry							1								
Research, organise, summarise and synthesise material.	1	1			1		1	1	1				1	1	
Critically evaluate and provide solutions of tasks set within the work environment.	1	1			1	1	1	1	1	1		1	1	1	
Able to be a critical consumer of research		1			1	1	1	1				1	1		
3 Critical self-awareness and personal literacy															
Integrate and become a valuable asset to a race team.	1						1	1	1						
Produce a Personal Development Plan to identify skill deficiencies and be able to produce reports to enable deficiencies to be remedied.	1						1								1
Be able to critically review and reflect on his or her experience and effectiveness in working in teams and have an understanding of team working.	1							1	1	1			1	1	
Set goals, manage time and tasks, and review personal performance to ensure that work is completed satisfactorily and on time.	1	1			1		1	1	1	1			1	1	

Work productively and effectively with others.	1			1	1	1			1	1	1		1	1	1
Listen and actively participate in discussions of relevant technologies and principles.	1	1		1	1	1			1	1			1	1	
4 Digital and Information Literacy															
Effectively use IT resources, including the internet and library databases, to search for and retrieve information.	1	1				1		1	1	1	1		1		1
Identify, evaluate and use automotive software.	1	1			1	1		1	1		1			1	
Be able to critically evaluate the validity and implications of information relevant to the programme of study and work.		1				1		1	1	1			1	1	1
Use appropriate technology to present ideas for oral and poster presentations, essays and reports.	1	1			1	1		1	1					1	1
5 Active Citizenship															
Understand the international dimension of motorsport engineering and working in international teams.	1							1	1					1	1
Design and manufacture of components or the development of best industry practice in a global market.	1	1			1			1						1	
With guidance, in relation to the field of Motorsport Engineering and within specified parameters, identify and explain issues related to ethics, health and safety, design, engineering science & applications, analytical & mathematical techniques, environmental considerations & sustainability, systems, management and economic factors.	1	1	1	1	1	1		1	1	1	1	1	1	1	1
In relation to Engineering, with clear guidance & support, work effectively within the boundaries imposed by ethical	1				1	1		1	1	1	1		1	1	1

and legal issues (including standards & codes) and demonstrate respect for the ethical and legal boundaries of other disciplines.															

Mapping Table

For each module whether the relevant graduate attribute is taught (T), practiced (P) and/or assessed (A) has been identified. This is detailed for each Graduate attribute under tasks, activities and assessments.

Graduate attribute	Module code	Attribute Taught (T), Practiced (P), Assessed (A)?	Tasks, activities, assessments
Academic literacy	ENGA4007	TAP	Demonstrate an appreciation for and provide a detailed account of Health and Safety in the workplace for employee responsibilities, PPE, risk assessment and common accidents. This would include the H&S issues related to products the company makes.
	ENGA4007	TAP	Provide a detailed account of production management techniques and processes that covers the use of any hand tools, machines, specialist equipment or processes within the workplace.
	ENGA4007	TAP	Describe the company structure in a way that includes evidence of the importance of a logical approach to engineering activities.
	ENGA4007	TAP	Describe what a cost factor is and identify those relating to the design, manufacture and/or servicing of a product in the workplace.
	ENGA4007	TAP	Provide an account of where Quality procedures have been implemented including knowledge and use of calibrating and measuring equipment or an appreciation of such processes in the work environment.
	ENGA4011	TAP	Use British Standard approaches to the CAD CAM design process.
	ENGA4011	TAP	Write a design specification
	ENGA4011	TAP	Complete a report for their design exercise based on a given specification
	ENGA4011	TAP	Collect and analyse technical and management information relevant to solving data based problems.
	ENGA4011	TAP	Collate data from investigations and produce written reports to identify solutions
	ENGA4009	TAP	Solve simple, defined engineering problems by selecting a suitable approach
	ENGA4009	TAP	Demonstrate the ability to apply techniques of differential and vector calculus to a range of engineering applications

Academic literacy continued	ENGA4009	TAP	Demonstrate the ability to use trigonometry to solve triangles
	ENGA4009	TAP	Model engineering problems in mathematical terms
	ENGA4010	TAP	Determine distribution of shear force, bending moment and stress due to bending in simply supported beams;
	ENGA4010	TAP	Determine the distribution of shear stress and angular deflection due to torsion in circular shafts;
	ENGA4010	TAP	Determine the behaviour of dynamic and / or oscillating mechanical systems in which uniform acceleration or Simple Harmonic Motion is present;
	ENGA4010	TAP	Describe the modes of heat transfer; Determine the rate of heat energy transfer rates in thermal systems;
	ENGA4010	TAP	Describe the effect of Bernoulli principles; Calculate pressure variations with fluid flow.
	ENGA4010	TAP	Describe lubricants used in race vehicles;
	ENGA4010	TAP	Apply relevant engineering science theory to mechanical systems;
	ENGA4010	TAP	Analyse and solve problems involving mechanical systems;
	ENGA4008	TAP	Define and evaluate the advantages & disadvantages of different materials.
	ENGA4008	TAP	Define the advantages and disadvantages of Thermosetting and Thermoplastic composites.
	ENGA4008	TAP	Describe the materials used in composite lay-up.
	ENGA4008	TAP	Determine what materials & processes are appropriate to particular technical requirements.
	ENGA4008	TAP	Understand the function, materials and manufacturing processes involved with automotive components and systems.
	ENGA4012	TAP	Analyse the effects of altering engine design factors
	ENGA4012	TAP	Calculate pressure, volume and temperature during the engine cycle using Thermodynamic equations.
	ENGA4012	TAP	Calculate torque, power, thermal efficiency, volumetric efficiency, MEP and specific fuel consumption;
	ENGA5017	TAP	Describe the purpose and rational for each section of an engineering report based on a generalised template but tailored to meet the professional requirements of the company in which the project is being undertaken so that they are able to produce a project report, including details of project management

Academic literacy continued	ENGA5010	TAP	Analyse the operation and interrelationship of the main vehicle chassis systems – steering, suspension, wheels and tyres – for performance vehicles both theoretically and practically;
	ENGA5010	TAP	Carry out calculations that analyse and reflect a full understanding under varying conditions of the main vehicle chassis systems – steering and suspension angles, suspension rates and tyre performance.
	ENGA5010	TAP	Analyse the operation and interrelationship of the main vehicle powertrain systems – transmission and braking – for performance vehicles both theoretically and practically;
	ENGA5010	TAP	Carry out calculations that analyse and reflect a full understanding under varying conditions of the main vehicle powertrain systems – torque, gear ratios, car performance and braking power.
	ENGA5010	TAP	Write a vehicle maintenance schedule and life chart, carry out tests to evaluate condition and suitability;
	ENGA5012	TAP	Apply engineering principles and analytical techniques in the design process.
	ENGA5012	TAP	Describe a range of finite element types and select those appropriate for modelling a specific design.
	ENGA5011	TAP	Analyse, test and calculate voltage, current, resistance and power in a range of vehicle automotive circuits;
	ENGA5011	TAP	Investigate the properties and characteristics of common semiconductor components;
	ENGA5011	TAP	Interpret and show a full understanding of circuit symbols and diagrams;
	ENGA5011	TAP	Develop, produce, analyse and evaluate an electronic system and explain operation;
	ENGA5011	TAP	Investigate, understand and use microprocessor architecture and operation;
	ENGA5011	TAP	Investigate microprocessor interfacing;
	ENGA5011	TAP	Analyse effective modern communication between vehicle microprocessors
	ENGA5015	TAP	Demonstrate the ability to apply techniques of integral calculus to a range of engineering applications
	ENGA5015	TAP	Demonstrate the ability to use matrix algebra to solve systems of equations
	ENGA5015	TAP	Use numerical and algebraic techniques to solve engineering problems
	ENGA5015	TAP	Demonstrate the ability to use probability and statistics in engineering problems
	ENGA5013	TAP	Apply the principles of geometric tolerancing as specified on engineering manufacturing drawings with reference to current British, European and International standards.
	ENGA5014	TAP	Explain different manufacturing management techniques and determine the various styles which are appropriate for given manufacturing tasks.

	ENGA5014	TAP	Apply relevant Management principals to enable the analysis and solution of manufacturing problems and be able to identify and understand the difference between “manufacturing” and “management” systems
Graduate attribute	Module code	Attribute Taught (T), Practiced (P), Assessed (A)?	Tasks, activities, assessments
Research literacy	ENGA4011	TAP	Evaluate the relevance of particular performance monitoring data acquisition software.
	ENGA4011	TAP	Describe the use of software programming languages
	ENGA4008	TAP	Present a report on the tools and processes used in materials testing.
	ENGA5017	TAP	Identify those tasks or operations that require the depth of research and investigation that justify selection to be run as a project and, through negotiation, agree suitable specifications and procedure
	ENGA5017	TAP	Undertake and critically analyse literature surveys for project using online and paper-based resources
	ENGA5010	TAP	Demonstrate knowledge of available types of lubrication systems
	ENGA5010	TAP	Understand and evaluate fasteners and fixings used in the Motorsport industry
	ENGA5012	TAP	Create a virtual prototype design of a part using CAE tools
	ENGA5016	TAP	Investigate and analyse fluid dynamic properties based on Motorsport Engineering principles
	ENGA5016	TAP	Compare and evaluate aerodynamic properties of vehicles and relate to road holding characteristics
	ENGA5016	TAP	Design, produce, test, analyse and evaluate aerodynamic properties using CFD and the wind tunnel.
	ENGA5016	TAP	Design a component/system and record the stages of the design process with suitable analysis
	ENGA5013	TAP	Identify the most appropriate manufacturing methods for economic manufacture and assembly of an existing and/or new product.
	ENGA5014	TAP	Describe the impact of new technologies and identify how they affect the management processes and practice in a manufacturing environment.

Graduate attribute	Module code	Attribute Taught (T), Practiced (P), Assessed (A)?	Tasks, activities, assessments
Critical self-awareness and personal literacy	ENGA4007	TAP	Provide a suitable logbook/journal that can be used as evidence demonstrating an acceptable level of performance, reflection and evaluation of learning
	ENGA4007	TAP	Demonstrate the ability to work in groups and teams including planning and organization of own work and how it combines with others in the team to produce the desired project outcome. Often this will be in multi-disciplinary activities.
	ENGA4007	TAP	Show project management skills that illustrate multiple activities. This should, ideally, include industrial involvement (i.e. involvement in a 'real' industrial problem) Work based mentor testimony will be assessed.
	ENGA4011	TAP	Present and report findings, recommendations and solutions in a coherent manner
	ENGA4010	TAP	Measure and evaluate experimental test data.
	ENGA4008	TAP	Understand the requirements for safe working, handling & storage of different materials. Exercise appropriate ethical judgment of environmental concerns and how safety can be ensured.
	ENGA5017	TAP	Show that they have grasped the need to implement the project within agreed procedures and to specification
	ENGA5017	TAP	Self-manage and evaluate their work
	ENGA5010	TAP	Carry out a full chassis set up of a performance vehicle in the workshop
	ENGA5012	TAP	Load, constrain and critically review FEA results
	ENGA5012	TAP	Give a well-structured group presentation
	ENGA5011	TAP	Analyse and evaluate the fundamental electrical characteristic operating principles of analogue and digital vehicle sensors and actuators;
	ENGA5014	TAP	Evaluate the impact of new technologies in manufacturing and how they relate to the design process so that they have a working knowledge of the need for design for manufacturing
Graduate attribute	Module code	Attribute Taught (T), Practiced	Tasks, activities, assessments

		(P), Assessed (A)?	
Digital and information literacy	ENGA4011	TAP	Use competently a digital/electronic design package to conceptualise and create a finished product and generate from that a set of engineering drawings that could be used in the lab rooms to create the desired part.
	ENGA5017	TAP	Identify and use the tools, skills and techniques necessary to give a presentation of the project outcomes to an audience using audio visual techniques
	ENGA5010	TAP	Record and analyse vehicle test data
	ENGA5010	TAP	Produce, use and analyse drawings of chassis and powertrain system layouts
	ENGA5012	TAP	Build and mesh finite element models
	ENGA5011	TAP	Analyse and develop electrical and microprocessor systems
	ENGA5013	TAP	Select and use appropriate computer numerical control software for component manufacture and be able to identify when CNC is the best choice for a sequence of manufacturing operations.
	ENGA5014	TAP	Identify and describe manufacturing quality systems.
Graduate attribute	Module code	Attribute Taught (T), Practiced (P), Assessed (A)?	Tasks, activities, assessments
Active citizenship	ENGA4012	TAP	Carry out a dynamometer test with analysis of the results.
	ENGA4012	TAP	Carry out a head flow test with analysis of results.
	ENGA4012	TAP	Specify components and systems for a given application including lubrication.
	ENGA5010	TAP	Describe and discuss the ergonomic and human factors related to performance car design and eligibility;
	ENGA5010	TAP	Understand and evaluate FIA/MSA rules and competition regulations against a vehicle, carry out checks to ensure this;
	ENGA5012	TAP	Work with others to produce a design prototype
	ENGA5011	TAP	Measure system outputs and inputs to determine affective operation and use
	ENGA5016	TAP	Present project findings in the form of a report and a presentation

SECTION 1: GENERAL INFORMATION

Awarding body:	**Oxford Brookes University**
Teaching institution and location:	**Bridgwater & Taunton College**
Final award:	**Foundation Degree (Engineering)- FdEng**
Programme title:	**Motorsport Engineering**
Interim exit awards and award titles:	**Certificate of Higher Education (exit award only)**
Brookes course code:	BW13
UCAS/UKPASS code:	**H33c**
JACS code:	H330
Mode of delivery:	**On campus**
Mode/s of study:	**Full time or part time**
Language of study:	**English**
Relevant QAA subject benchmark statement/s:	Foundation degree benchmark (2015) QAA Engineering benchmark (2015) QAA Quality Code for Higher Education (2018) Engineering Council UK-SPEC (Third Edition): http://www.engc.org.uk/ukspec.aspx
External accreditation/recognition: *(applicable to programmes with professional body approval)*	Partial IEng with the IET (http://www.theiet.org/) and the IMechE (http://www.imeche.org/).
Faculty managing the programme:	Faculty of Technology, Design & Environment
Date of production (or most recent revision) of specification:	March 2019

SECTION 2: OVERVIEW AND PROGRAMME AIMS

2.1 Rationale for/distinctiveness of the programme

This course is a two year Foundation Degree programme designed to enable students with a relevant L3 qualification in an Automotive or Engineering subject, or equivalent, to obtain a FdEng in Motorsport Engineering.

It has been developed with Oxford Brookes University and has both a work placement and project element so that students can tailor their course to the needs of industry. The programme will utilise its facilities to provide students with the same opportunities as those on similar courses offered at Oxford Brookes University. Cohort size will follow a similar pattern to that of the in-house BSc(Hons) course and will allow natural progression in a familiar environment to that of the previous course studied (i.e. Extended Diploma in Motorsport).

Local employers such as Anderson Racing Engines and Mark Bailey Racing will be regularly contacted to ensure the programmes relevance to industry and that the facilities, software and equipment is to the correct standards. Students have the opportunity to be involved with the college race team and be able to carry out work placements during the first year. Visits to industry and guest speakers are also a common theme within the course. Trips to companies for students and staff such as Xtrac Engineering and Force India F1 allow staff to keep up to date with modern day industry practises and implement this into teaching sessions and laboratory work.

Graduates from the course will have a range of skills and knowledge to help them progress into the workplace or onto a higher level degree course.

The course will give students a range of both practical and theoretical skills that can be utilised in industry. The range of modules gives good coverage to a wide range of topics, allowing students to explore the areas of Motorsport that they wish to specialise in. The Project and Work placement modules give them the chance to further look into potential career paths and challenge themselves both in a working environment and with a self-study project module.

2.2 Aim/s of the programme

The Foundation Degree in Motorsport Engineering is designed to meet the following aims:

- to provide a professional foundation for a range of technical and management careers in Motorsport Engineering;
- to provide a broad range of studies directly relevant to a wide range of Motorsport related careers;
- to enable students to make an immediate contribution in their current employment through skills learnt and in particular via a work related project;
- to provide flexibility, knowledge, skills and motivation as a basis for career development and as a basis for progression to graduate and postgraduate studies;
- to develop students' ability in Motorsport Engineering through effective use and combination of the knowledge and skills gained in different parts of the programme and in the workplace;
- to develop a range of skills and techniques, personal qualities and attitudes essential for reflective learning and practice leading to successful performance in working life through the integrated assessment of Professional/Transferable Skills;
- to provide individuals with the skills necessary to progress their career in Motorsport Engineering;
- to provide pathways onto full Motorsport Engineering Degrees at Bridgwater & Taunton College, Oxford Brookes or other Universities. For the College, this is a direct one year top up, being a BSc (Hons) Motorsport Technology. At Brookes, this can mean joining the third year of a BSc (Hons) degree or the second year of a BEng (Hons) programme. Both these routes can then lead into a Masters programme.

SECTION 3: PROGRAMME LEARNING OUTCOMES

The learning outcomes of all Oxford Brookes courses including those at the UCS are expressed in terms of graduate attributes. These attributes describe the characteristics that students learning on Oxford Brookes University programmes will ideally have upon graduation. As a tool for planning and design, they represent knowledge, skills and perspectives that our graduates will have developed through studying on Brookes programmes and which can help equip them for life in the 21st century. Promoting personal development, they can prepare graduates for successful and rewarding employment.

The Foundation Degree programme has been designed to support students to develop five graduate attributes as follows:

- Academic literacy;
- Research literacy;
- Critical self-awareness and personal literacy;
- Digital and information literacy;
- Active citizenship.

Graduate Attributes are those core personal and academic skills which are developed in graduates of all Oxford Brookes University degree programmes.

The learning outcomes of the Programme, and of each module, are listed under these five graduate attributes. Each module outline indicates the graduate attributes that you will develop

Academic literacy
Academic literacy starts with Mathematics, which provides the tools required to study and understand engineering principles in statics, dynamics, thermodynamics and materials as taught in your previous course. Many of these modules are centred around the College Race Team. As the programme develops, you can expect to measure and test physical theory and relationships in the lab in parallel with the academic literacies that you are acquiring through lectures, tutorial work and self-study, following the constructive alignment described in the University Assessment Compact (see Appendix 1).

Research literacy
Research literacy is a constant theme that appears again and again throughout the programme, from simple report formatting in the first year of your previous course to more extended pieces of lab work and library research in its second year. In these modules you will apply skills and research literacies gained in earlier modules to enable you to plan an original piece of work, carry out the necessary research to familiarise yourself with current work and then build on the existing work to make new, original and novel contributions to the subject of study. The combination of group and individual project work in your third year gives you the necessary research and group working skills to enable you to progress to being useful employees within a short period of time in your first career appointment.

Critical self-awareness and personal literacy
This Graduate Attribute is addressed in a number of modules in your previous course combining science, engineering, materials, crafting skills and report writing techniques. The project module ENGA5017 features critical assessment of one’s own work and the work of others while preparing and planning the project.

Digital information literacy
Graduates of the programme necessarily have very well developed computer based analytical skills because of the large amount of computer software used in the design and analysis of

Motorsport artefacts. However, the graduate attribute, 'Digital information literacy' extends beyond this to include the use of computers for more general skills such as presentations, literature reviews, preparation of design reports etc. Several modules all provide the opportunity to gain these digital literacy skills.

Active citizenship
This graduate attribute relates to how well the graduates of the programme are prepared for work in the international and global business context.

How each module contributes to the programme learning outcomes is shown in the table below:

On successful completion of the programme, graduates will demonstrate the following Brookes Attributes informed by the subject benchmark statements for Engineering in the form of UKSPEC 3rd Edition 2013 https://www.engc.org.uk/ukspec.aspx

Academic literacy

a) Understand and use the scientific principles which underpin the design and operation of mechanical systems.
b) Understand the day to day running of a professional team in both management and technical areas.
c) Have a good understanding of modern systems within a vehicle and advanced technology integration and development.
d) Apply appropriate mathematical principles to problems in Motorsport Engineering.
e) Design and implement management structures within an organisation.

Research literacy

a) Design, manufacture and test components to develop and enhance a vehicle system.
b) Be able to maintain and manage a major piece of research work linked to industry
c) Research, organise, summarise and synthesise material.
d) Critically evaluate and provide solutions of tasks set within the work environment.
e) Able to be a critical consumer of research

Critical self-awareness and personal literacy

a) Integrate and become a valuable asset to a race team.
b) Produce a Personal Development Plan to identify skill deficiencies and be able to produce reports to enable deficiencies to be remedied.
c) Be able to critically review and reflect on his or her experience and effectiveness in working in teams and have an understanding of team working.
d) Set goals, manage time and tasks, and review personal performance to ensure that work is completed satisfactorily and on time.
e) Work productively and effectively with others.
f) Listen and actively participate in discussions of relevant technologies and principles.

Digital and information literacy

a) Effectively use IT resources, including the internet and library databases, to search for and retrieve information.
b) Identify, evaluate and use automotive software.
c) Be able to critically evaluate the validity and implications of information relevant to the programme of study and work.

d) Use appropriate technology to present ideas for oral and poster presentations, essays and reports.

Active citizenship

a) Understand the international dimension of motorsport engineering and working in international teams.
b) Design and manufacture of components or the development of best industry practice in a global market.
c) With guidance, in relation to the field of Motorsport Engineering and within specified parameters, identify and explain issues related to ethics, health and safety, design, engineering science & applications, analytical & mathematical techniques, environmental considerations & sustainability, systems, management and economic factors.
d) In relation to Engineering, with clear guidance & support, work effectively within the boundaries imposed by ethical and legal issues (including standards & codes) and demonstrate respect for the ethical and legal boundaries of other disciplines.

SECTION 4: PROGRAMME STRUCTURE AND CURRICULUM

4.1 Programme structure and requirements:

Module Code	Module Title	Credits	Level	Status	Semester of delivery	Pre-requisites
ENGA4007	Work Based Module	30	4	Core	1&2	N/A
ENGA4011	CAD CAM and Data Acquisition & Analysis	30	4	Compulsory	1&2	N/A
ENGA4009	Mathematics I	15	4	Core	1	N/A
ENGA4010	Engineering Science	15	4	Compulsory	2	N/A
ENGA4008	Composites and Materials Technology	15	4	Compulsory	1	N/A
ENGA4012	Engine Technology	15	4	Core	2	N/A
ENGA5017	Work Based Project	30	5	Compulsory	1&2	ENGA4007
ENGA5010	Vehicle Dynamics & Performance Engineering	30	5	Compulsory	1&2	ENGA4011 ENGA4012
ENGA5012	Computer Aided Engineering	15	5	Compulsory	1	ENGA4011 ENGA4008
ENGA5011	Vehicle Electronics and Microprocessors	15	5	Compulsory	2	N/A

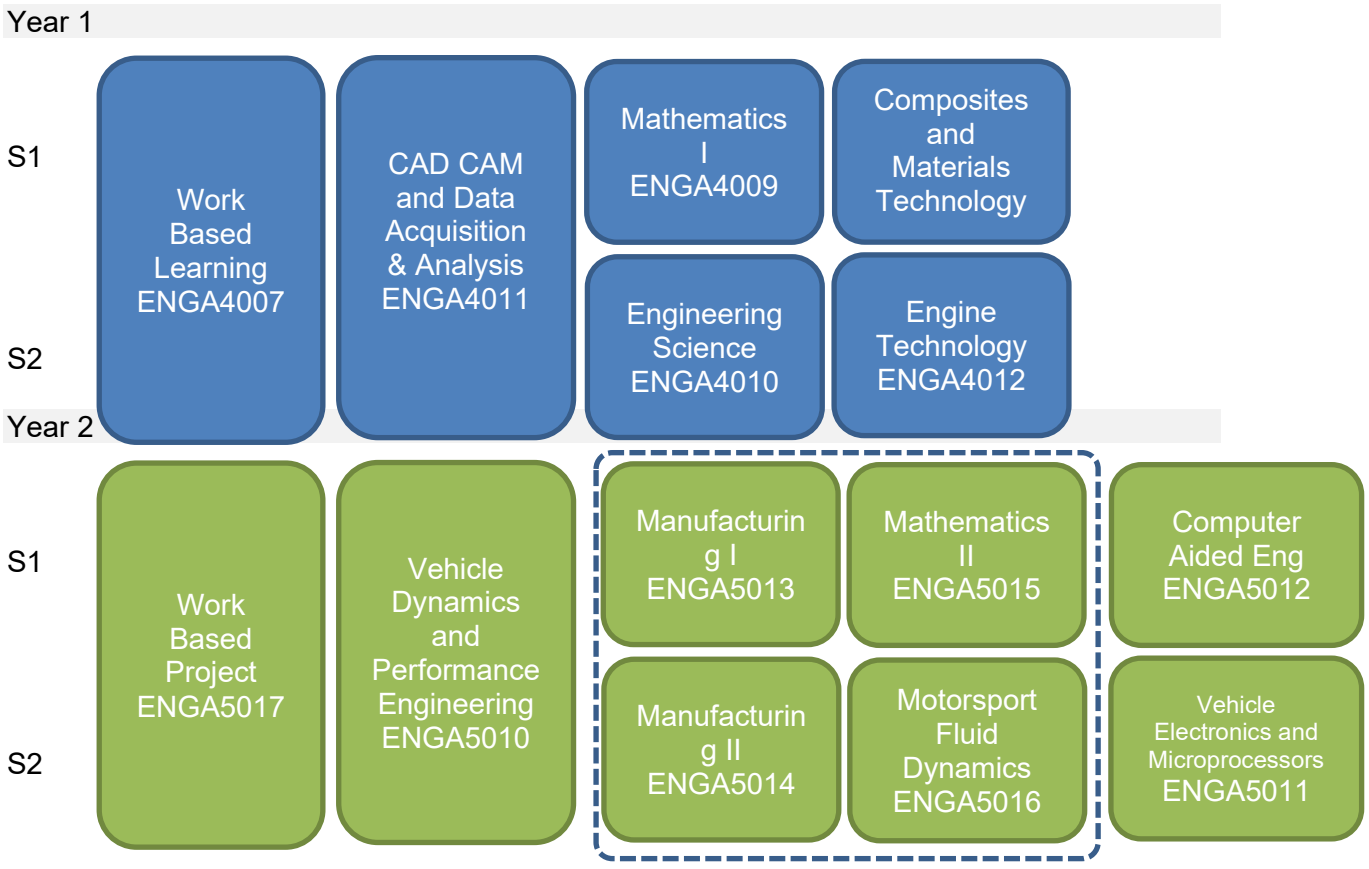
ENGA5015	Mathematics II	15	5	Optional*	1	ENGA4009
ENGA5016	Motorsport Fluid Dynamics	15	5	Optional*	2	ENGA4011 ENGA4009 ENGA4010
ENGA5013	Manufacturing I	15	5	Optional	1	ENGA4007 ENGA4008
ENGA5014	Manufacturing II	15	5	Optional	2	ENGA5013

*Mathematics II and Motorsport Fluid Dynamics are compulsory for students who wish to progress to Level 6 of the BSc (Hons) Mechanical Engineering degree.

Note that the run of optional modules is dependent on student numbers.

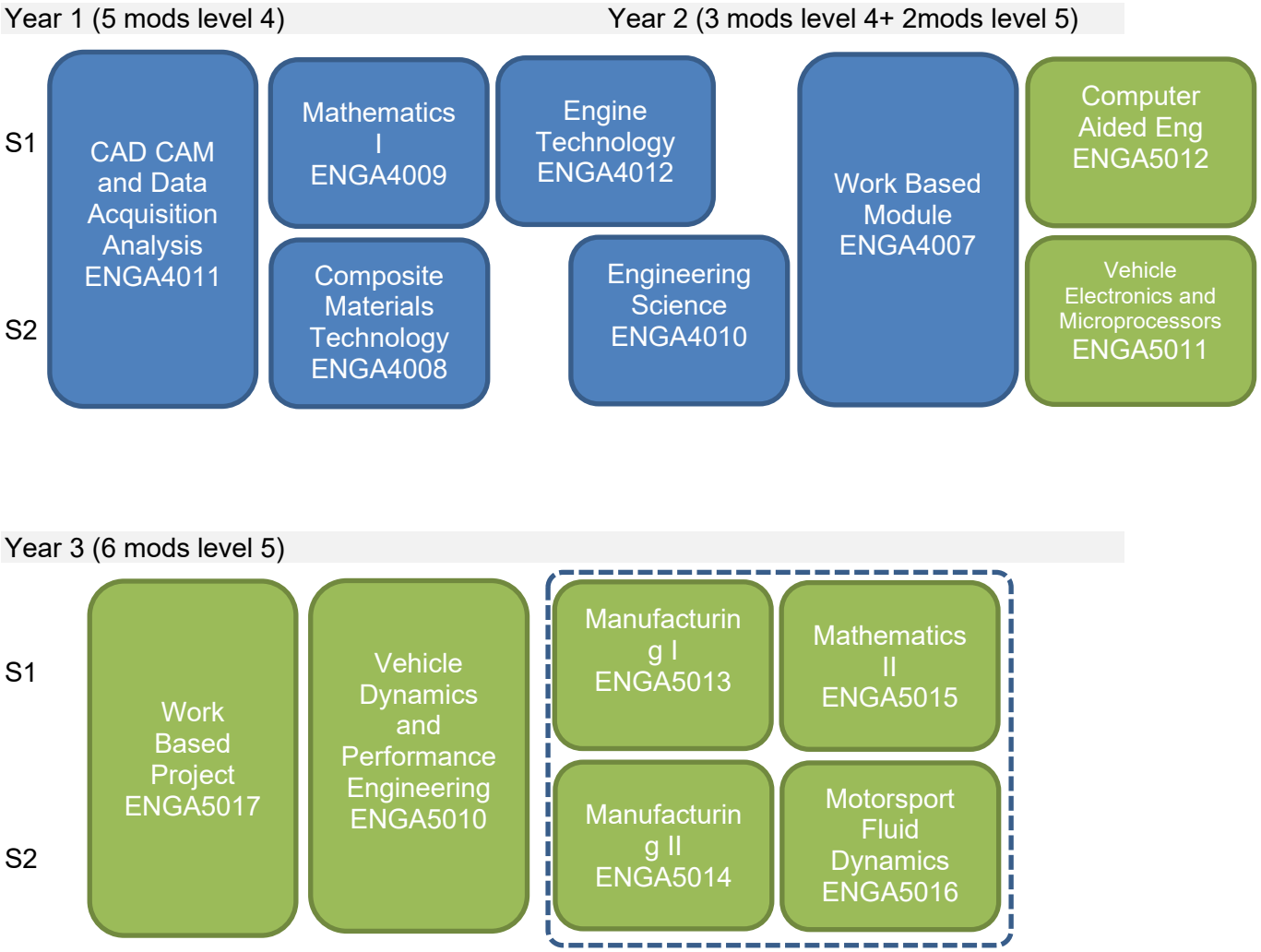
4.1.1 Full time programme structure:

The structure of the full-time course is shown by the subject diagram (the dashed line means the students take 2 out of the 4 modules):



4.1.2 Part-time 3 years programme structure:

The structure for the 3 years part-time course is shown by the following diagram (the dashed line means the students take 2 out of the 4 modules):



Progression Rules**:**
To progress from Level 4 to Level 5 a student must have achieved at least 90 credits at Level 4 including the core modules. If a student does not achieve 90 credits at Level 4 or one of the core modules he/she will continue with a revised programme of studies which can include Level 5 modules for which the pre-requisites have been passed.

4.2 Professional requirements

Any combination of the optional modules grants the students an accredited FdEng degree.

ADMISSIONS

Entry criteria

Typically entrants will possess

- a minimum of one pass at A-level or 6-unit Vocational A-level (in Maths, Physics or a closely related subject), plus a minimum of three passes at GCSE (grades A-C) including Mathematics at grade B or equivalent and English language.

OR

- a National Certificate or Diploma or other full equivalent Level 3 qualification, in a discipline related to Engineering, including merits in the applied units, plus a minimum of three passes at GCSE (grades A-C) including Mathematics at grade B or equivalent and English language.

Students with a minimum of two years of relevant work experience and a current role in an appropriate workplace setting that have a line manager's letter of support and recommendation are encouraged to apply.

Work-based learning is an integral part of the Foundation Degree programme. Thus, a key characteristic of a Foundation Degree is close co-operation with relevant employers. Entrants to the programme will be expected to have the support of their employer and will need to demonstrate the employer will provide the opportunity for work-based learning, e.g. a letter of employer support with the application form. For full-time students, arrangements will be made to identify appropriate work placement in advance of admission. It follows that in order to undertake the assessment on the programme, a student must have access to an appropriate work environment (voluntary or paid; full-time, part-time or work placement). If during the course of the programme a student loses their work or access to the work-place then alternative arrangements, if feasible, must be made as soon as possible. Whilst the college will facilitate as far as possible, fundamentally, it remains the learner's responsibility to secure such access in order to complete the assessment on the programme.

Applicants are normally interviewed and may be required to undertake numeracy and literacy tests as part of the assessment by the College, especially where experiential learning is used to support admission, to ensure that they possess the appropriate attributes to succeed on the programme and to check on the suitability of the work environment to which applicants have access.

Full-time students apply through UCAS, while part-time students may apply direct to the College for admission to the Foundation Degree.

Admission with Credit

Applicants with prior certificated or experiential learning may be admitted with credit for up to a maximum of 120 credits at Level 4 and 30 credits at Level 5. Applications for the award of credit must be made in writing following discussion with the College programme lead and the University's Liaison Manager. Documentary evidence will be required in support of the application.

English Language Requirements

Applicants whose first language is not English must also demonstrate that their level of English is acceptable, by achieving a score in a recognised test such as British Council IELTS (normally minimum Level 6.0 overall with a minimum of 6.0 in reading and writing, 5.5 in listening and speaking).

The University's English language requirements can be found at http://www.brookes.ac.uk/international/how-to-apply/undergraduate/undergraduate-entry-requirements/

CRB checks
CRB checks are not applicable to this programme.

SECTION 5 - Module Details
LEVEL 4 MODULES

MODULE TITLE:	**Work Based Learning**
MODULE NUMBER:	**ENGA4007**

1. MANAGEMENT DETAILS	
Module leader:	Josh Smith
Level:	4
No. of credits:	30
Mode of delivery:	Blended Learning
Pre-requisites:	N/A
Co-requisites:	None
Barred combinations:	None
Other restrictions or requirements:	Must be carried out in a work, or work placement, engineering, industrial or technology working environment.
Timetable information:	Semesters 1 & 2, 28 weeks

Programme/s in which this module may be taken	**Status on programme**
FdEng Motorsport Engineering- BW13	Compulsory

2. MODULE AIMS

In this module, through work based study, students will gain an introduction to the management, planning, use and fabrication of materials, for manufacturing processes. The module is designed to raise students' awareness of the realities of present-day industrial processes so that are able to direct and apply them in a work environment. This module will provide opportunities for the students to apply their knowledge of Engineering Principles to practical engineering problems in the context of design, manufacture, construction, assembly, commissioning, operation, maintenance, reliability and quality of products and systems. Particular attention should be paid to how the company is structured and how these engineering applications facilitate production methods. In carrying out these tasks students will need to understand and apply the international standards used in many operations and techniques common to their industry.

3. LEARNING OUTCOMES		
On successful completion of this module, students will be able to:	** Brookes Attribute developed*	*Other GAs developed, if applicable*

1. Demonstrate an appreciation for and provide a detailed account of Health and Safety in the workplace for employee responsibilities, PPE, risk assessment and common accidents. This would include the H&S issues related to products the company makes.	Academic Literacy	Active Citizenship, Critical Self-Awareness and Personal Literacy
2. Provide a detailed account of production management techniques and processes that covers the use of any hand tools, machines, specialist equipment or processes within the workplace.	Academic Literacy	Critical Self-Awareness and Personal Literacy, Research Literacy, Active Citizenship
3. Describe the company structure in a way that includes evidence of the importance of a logical approach to engineering activities.	Academic Literacy	Critical Self-Awareness and Personal Literacy
4. Describe what a cost factor is and identify those relating to the design, manufacture and/or servicing of a product in the workplace.	Academic Literacy	Critical Self-Awareness and Personal Literacy
5. Provide an account of where Quality procedures have been implemented including knowledge and use of calibrating and measuring equipment or an appreciation of such processes in the work environment.	Academic Literacy	Critical Self-Awareness and Personal Literacy
6. Provide a suitable logbook/journal that can be used as evidence demonstrating an acceptable level of performance, reflection and evaluation of learning.	Critical Self-Awareness and Personal Literacy	Digital and Information Literacy
7. Demonstrate the ability to work in groups and teams including planning and organization of own work and how it combines with others in the team to produce the desired project outcome. Often this will be in multi-disciplinary activities.	Critical Self-Awareness and Personal Literacy	Academic Literacy, Research Literacy
8. Show project management skills that illustrate multiple activities. This should, ideally, include industrial involvement (i.e. involvement in a 'real' industrial problem) Work based mentor testimony	Critical Self-Awareness and Personal Literacy	Active Citizenship, Academic Literacy, Research Literacy

*More details about the Brookes graduate attributes are available online at http://www.brookes.ac.uk/services/ocsld/sese/graduate_attributes.pdf.

UK-SPEC Learning Outcomes completed in this module:

The learning outcomes definition can be found, for example in the IET handbook of learning outcomes: http://www.theiet.org/academics/accreditation/policy-guidance/handbook_lo.cfm

US1i	US2i					

E1i	E2i	E3i	E4i			
✓	✓	✓				
Di1	D2i	D3i	D4i	D5i		
✓	✓	✓	✓	✓		
S1i	S2i	S3i	S4i	S5i		
✓	✓	✓	✓	✓		
P1i	P2i	P3i	P4i	P5i	P6i	P7i
✓	✓	✓	✓	✓	✓	✓

4. OUTLINE SYLLABUS

Health & Safety Legal responsibilities of the individual and the employer

- Introduction to Health and Safety (H&S) in the workshop/manufacturing areas, risk assessment for new tools, processes and working environments, legislation relating to individual and corporate responsibility, safety reviews and processes after an accident - underlying principles of safety assessment of equipment, environment and processes.

Manufacturing Processes, management structure and organisation

- Management styles that are current and applicable to this and different industry sectors, flexible and lean manufacturing, JIT and other relevant organisational processes. Define and identify cost factors to gain knowledge and understanding of how they affect design and manufacturing decisions. Principles of leadership, pyramid and devolved leadership management models.
- As new technologies and materials are introduced, engineers need multidisciplinary skills, and the way you implement this in your assessments should reflect this. You should, wherever possible, choose engineering applications that relate to each student's chosen discipline: for example, for manufacturing engineer, workshop methods involving hand tools, production methods and quality testing should probably be related to the industry's manufacturing methods. The Modules are designed to contribute to UK-SPEC. Your tutor will advise you on the full process
- Quality standards and processes including inspection and test, calibration of equipment working to British, European and International standards. Different approaches to managing quality, reducing defects and dealing with recalls and reworking for components/products.
- Students will be allocated an academic supervisor. The Unit requires the student to produce a logbook/journal and receive a satisfactory report from the work place.

Group working in inter-disciplinary projects

- Team dynamics, team leadership, individual and collective responsibility, organisation and effective team management, dealing with under-performance, identifying and recognising outstanding performance above the norm.
- Project management styles and requirements, monitoring progress, planning, budget control and professional standards in the workplace.

Work Placement

- Students will gain specific skills, knowledge and understanding in a related industry that will enhance their learning in production, services and manufacture. They will be expected to complete a minimum of 30 days within a calendar year (date to be set by module leader).

Workshop Practice

- Learners will make use of a range of hand skills and machine operations in order to produce a stub axle assembly. They will in particular make use of mills and lathes to machine each part of the assembly whilst accurately using precision measurement equipment and the machines digital read outs in order to produce their finished part.

5. TEACHING LEARNING AND ASSESSMENT STRATEGY

In addition to meeting the requirements of Graduate Attributes, the module must contribute to the learning outcomes matrix defined in UKSPEC by the IET and IMechE. A table showing this contribution is provided above at the end of section three.

Throughout this 2 – part module students will have a named workplace supervisor but it is more than likely that they might be required to work for and report to other employees and staff with supervising responsibilities within the workplace. Both these scenarios are valid and will impact on the assessment produced by the company on the student's performance. In addition the student will create and keep a professional log book in a format commensurate with that of a Continuing Professional Development log book in the style approved by the IMechE and/or IET. This will be how the student demonstrates their knowledge, understanding and achievement and has scope for the work placement supervisor to incorporate their assessment of the student's development and competence in the Learning Outcomes defined for the module. The campus based workshop element allows learners to develop the learning outcomes in a controlled and observed environment using the college facilities. The assessment methods allow learners to produce a finished assembled component whilst their working practices are assessed in the form of an exam.

Graduate attributes are met in the following ways:

1. Academic Literacy

The treatment of academic literacy includes the knowledge, compliance and when necessary application of H&S procedures. Through the observation and understanding of logical decisions that improve manufacturing processes and productivity students gain the necessary knowledge and ability to select and apply appropriate manufacturing processes and equipment in their working environment. As this module takes place in the work, or work placement, environment students gain a holistic view of the business they are employed in. The outcomes numbered one through five provide students with numerous examples of opportunities that exist in the workplace and workshop to teach, practice and assess the learning outcomes described and gain academic literacy relevant to their employment. Learners will improve their hand skills and understanding of manufacturing production and quality control whilst reading from technical drawings to produce a finished component.

2. Research literacy

It is inevitable that some roles and duties of a student in the workplace will require them to research and use the results of research to complete tasks and responsibilities that they are given but these are not explicitly taught, practiced or assessed in this module as they will be variable in number and quality.

3. Critical self-awareness and personal literacy

Is developed by students being responsible for summarising the key academic literacy points that they record in their logbook and the steps they have taken in their component manufacture. Making sure that it not only describes a brief description of the task but relates it to the learning

outcomes and graduate attributes of the module and specifically the UKSPEC learning outcomes that are the QAA and Engineering council benchmark statements. There is adequate provision for not only an explanation of how a specific learning outcome is achieved but critical evaluation and reflection by the student in relation to the existing processes, their ability to fulfil the requirements and subsequent reflection on ways to improve their performance and/or the process itself. The opportunities to be taught, and to practice this attribute are in outcomes six through eight and it will be assessed by supervisors specifically in outcome six but also throughout the majority of outcomes in this module.

4. Digital Information Literacy.

Is developed through the requirement to use computer systems, measurement equipment and digital read outs in the workplace and workshop as well as prepare a typed placement report that includes input samples from their work experience using different organisational, manufacturing, management and analytic digital systems. Where possible this should be an active live document in the form of Google or Onedrive documents or a wikki so that students and staff can see the report grow and evolve. Outcome six provides every student with the same opportunity to be assessed but in the course of the placement there will be numerous opportunities for students to be shown (taught), use (practice) and report back (assessed) to their supervisor experiences that impart digital information literacy.

5. Active citizenship

Students will gain experience in dealing with communication through drawings and dimensions that are universally used in engineering companies in both parts of the module.

6. LEARNING HOURS *(10 notional learning hours per credit)*	
Scheduled learning and teaching activities *(contact hours)*	
Lectures	6 hours
Seminars	0 hours
Practical classes/workshops	50 hours
Tutorials	6 hours
Fieldwork/external visits	0 hours
Guided independent study	
Directed/independent study	14 hours
Preparation for assessments	14 hours
Placement/Study Abroad	
Placement	210 hours (30 days)
TOTAL:	**300 hours**

7. ASSESSMENT TASKS

7.1 Summative assignments (indicative)

Describe assessment tasks below…	Word count/ length of exam	Learning outcomes assessed	Weighting	KIS category
Coursework				
One log book of approximately 30 pages assuming 300 words per page totalling 9000 words maximum excluding titles, pictures and references.	9000 words	1, 2, 3, 4, 5, 6, 7, 8	50%	1
Coursework 2: Lab report from machine shop and component submission	2000 words	1,2,4,5,7,8	20%	1
Written examinations				
Exam	2 hours	1,2,4,5	30%	2
Other				
			%	

7.2 Opportunities for formative assessment and feedback

The log book will be kept in a style commensurate with a Continuing Personal Development record as approved by the relevant Professional Statuary Body (PSB) either the IMechE or the IET. This format will provide opportunity for workplace supervisors and/or academic staff to make comments on the relation that the student has made between the tasks and work responsibilities he/she has taken responsibility for and the learning outcomes and graduate attributes of the module. It should be reviewed on at least a monthly basis but preferably weekly or fortnightly to ensure that coursework is continuously assessed and improved on.
The work in the machine shop on site will provide constant formative assessment for learners as they machine each part of their assembly whilst a mock exam will allow them to prepare for the end of year exam.

8. INDICATIVE READING LIST

- Bailey, T., Hughes, K. and Moore, D. (2002) Work Based Learning, USA:Westview Press Inc (The Perseud Books Group), USA.
- Boud, D. and Solomon, N. (2001) Work-Based Learning: A New Higher Education, London: Open University Press, UK.
- Chalkley, B. (2000) Improving Students' Skills Through Work-based Learning, London: Cheltenham & Gloucester College of Higher Education, Geography Discipline Network (University of Gloucestershire), UK.
- Hall, H. (2004) *Milling: A Complete Course.* Special Interest Model Books
- Hall, H. (2003) *Lathework: A Complete Course.* Special Interest Model Books
- Portwood, D. and Costley, C. (2000) Work Based Learning and the University: New Perspectives and Practices, London: SEDA, UK .
- Raelin, J. (1999) Work-based Learning: The New Frontier of Management Development, London: Addison Wesley (Pearson Education Ltd), UK.
- Ruth Helyer, (2010) The Work-Based Learning Student Handbook, Palgrave Study Skills, UK
- Hughes, P. and Ferrett, E. (2011) Introduction to health and safety at work: the handbook for the NEBOSH National General Certificate. 5th edn. Kidlington: Butterworth-Heinemann.
- Tooley, M. and DIngle, L. (2004) Higher national engineering. 2nd edn. Oxford: Newnes.
- Smith, N.J. (ed.) (2008) Engineering project management. 3rd edn. Blackwell Publishing.

Date module first approved:	2010
Date of most recent revision:	April 2015

MODULE TITLE:	**CAD CAM and Data Acquisition & Analysis**
MODULE NUMBER:	**ENGA4011**

1. MANAGEMENT DETAILS	
Module leader:	Josh Smith
Level:	4
No. of credits:	30
Mode of delivery:	face to face
Pre-requisites:	N/A
Co-requisites:	N/A
Barred combinations:	None
Other restrictions or requirements:	None
Timetable information:	Semesters 1 & 2, 28 weeks

Programme/s in which this module may be taken	**Status on programme**
FdEng Motorsport Engineering- BW13	Compulsory

2. MODULE AIMS

The aims of this module are:

- to give students an opportunity to experience the process of carrying out a design project that will enable them to engage with the international nature of engineering and manufacture design. By completing the various assessments the students will be in a position to appreciate that design involves synthesising parameters which will affect the design solution and this will be emphasised by looking at the impact of a variety of work from internationally recognised designers in motorsport.
- to learn how to use computers as an aid for solving engineering problems. The module utilises modern data analysis software to interrogate and analyse data from a race car in order develop both the vehicle systems and driver. The module is heavily based on the use of industry standard software and will allow learners to be adaptable in their application of different software and computer systems.

3. LEARNING OUTCOMES

On successful completion of this module, students will be able to:	** Brookes Attribute developed*	*Other GAs developed, if applicable*
1. Use British Standard approaches to the CAD CAM design process.	Academic Literacy	Research Literacy, Active Citizenship
2. Write a design specification	Academic Literacy	Research Literacy
3. Complete a report for their design exercise based on a given specification	Academic Literacy	Research Literacy
4. Use competently a digital/electronic design package to conceptualise and create a finished product and generate from that a set	Digital and Information Literacy	Active Citizenship

of engineering drawings that could be used in the lab rooms to create the desired part.		
5. Collect and analyse technical and management information relevant to solving data based problems.	Academic Literacy	Digital and Information Literacy
6. Evaluate the relevance of particular performance monitoring data acquisition software.	Research Literacy	Critical Self-Awareness and Personal Literacy
7. Describe the use of software programming languages	Research Literacy	Digital and Information Literacy
8. Collate data from investigations and produce written reports to identify solutions	Academic Literacy	Digital and Information Literacy
9. Present and report findings, recommendations and solutions in a coherent manner	Critical Self-Awareness and Personal Literacy	Active Citizenship, Digital and Information Literacy

*More details about the Brookes graduate attributes are available online at http://www.brookes.ac.uk/services/ocsld/sese/graduate_attributes.pdf.

UK-SPEC Learning Outcomes completed in this module:

The learning outcomes definition can be found, for example in the IET handbook of Learning outcomes: http://www.theiet.org/academics/accreditation/policy-guidance/handbook_lo.cfm

US1i	US2i					
✓						
E1i	E2i	E3i	E4i			
	✓	✓				
Di1	D2i	D3i	D4i	D5i		
✓	✓		✓			
S1i	S2i	S3i	S4i	S5i		
✓	✓	✓	✓	✓		
P1i	P2i	P3i	P4i	P5i	P6i	P7i
		✓	✓	✓		

4. OUTLINE SYLLABUS

Design specification

- Customer requirements: all relevant details of customer requirements (aesthetics, Functions, performance, cost, production parameters) are identified and listed.
- Design parameters: Implications of specification parameters and resource requirements are identified and matched, the level of risk associated with each significant parameter is established.

- Design information: All relevant information is extracted from appropriate reference sources, techniques and technologies used in similar products are identified, when new technologies can be used, these are specified, relevant standards and legislation are identified and applied throughout.

Design report

- Analysis of possible design solutions: Selection and use of appropriate analysis techniques.
- Evaluation: Costs, future, development potential, value engineering concepts.
- Compliance check: Using checklists, design review procedures.
- Report: Communicate rationale for adopting proposed solution, use of appropriate techniques and media in presentation of the report.

Computer-based technology

- Key features of computer-aided design system: 2D design and 3D modelling systems, e.g. standards, parts and materials, engineering calculations, layouts.
- Software: accessing and using appropriate design software
- Technical applications
- Management applications – statistics and budgets. Communications and records.
- Data Logging using Data from the college race team and other sources for sample files
- Application of Telemetry
- Spread sheet production and manipulation
- Extraction of data from a race car
- Knowledge of systems and hardware used within the industry

5. TEACHING LEARNING AND ASSESSMENT STRATEGY

Attributes are met in the following ways:

Academic Literacy

The treatment of academic literacy includes the knowledge, compliance and application of the LO's listed in section 3. These outcomes provide students with numerous opportunities to practice and assess the learning outcomes described and gain academic literacy relevant to the design process. The tuition delivered to enable students to gain this GA will be the result of the learning activities listed in section 6.

Research literacy

The assignments set will require students to research and use the results of that research to create their own design based on an established paradigm. The academic knowledge they have acquired will enable them to select and apply the design process that best suits the engineering problem posed and so complete the assignment tasks. There will be specific exercises, with in-class support, that require students to research and apply the relevant design processes given them the opportunity to practice applying the results of their research before the final assessments. Collation and analysis of sample data files coupled with applied learning of relevant software allows the learner to create their own results to produce a structured analytical report.

Digital Information Literacy.

Is developed through the requirement to use computer software and related systems as well as prepare a suitably formatted report all of which demonstrate knowledge and aptitude for digital information literacy.

Active citizenship

Is developed through the requirement to use software essential to the profession of mechanical/ manufacturing engineer. Furthermore and the ability to communicate design and manufacturing

information is a key element (along with the generic understanding of vehicle performance) of Active citizenship from the perspective of engineering and science.

In addition to meeting the requirements of Graduate Attributes, the module must contribute to the learning outcomes matrix defined in UKSPEC by the IET and IMechE. A table showing this contribution is provided above at the end of section three.

6. LEARNING HOURS *(10 notional learning hours per credit)*	
Scheduled learning and teaching activities *(contact hours)*	
Lectures	56 hours
Practical classes/workshops	56 hours
Guided independent study	
Directed/independent study	94 hours
Preparation for assessments	94 hours
Placement/ Study abroad	
	0 hours
TOTAL:	**300 hours**

7. ASSESSMENT TASKS

7.1 Summative assignments (indicative)

Describe assessment tasks below…	Word count/ length of exam	Learning outcomes assessed	Weighting	KIS category
Coursework				
Assignment 1: CAD Assignment with group presentation	15 minutes	1-4,9	25%	1
Assignment 2: CAM Assignment	2500 words	1-4,9	25%	1
Assignment 3: Data Acquisition and Analysis Assignment	5000 words	5-9	50%	1
Written examinations				
N/A				
Other				
N/A				

7.2 Opportunities for formative assessment and feedback

Students will be set regular formative assessments in the form of case studies and task sheets presented through the VLE or simple design exercises with sample solutions that are peer assessed using the sample exercises as a marking guide.

Overall progress is monitored through formative feedback and regular meetings with the module leader and course tutor. An open door staffroom policy also gives students the opportunity to discuss coursework and assessment with the module leader. Design and operational based presentations also allow staff to assess students knowledge and understanding.

8. INDICATIVE READING LIST

- Books,T. (2015) *SolidWorks 2015 Learn by doing.* CreateSpace Independent Publishing Platform
- Budynas, R. G. and Nisbett, K. (2014) *Shigley's Mechanical Engineering Design*, London: McGraw-Hill.
- Corbett, J., Dooner, M., Meleka, J. and Pym, C. (1991) *Design for Manufacture*, London: Addison-Wesley.
- Cross, N. (2008) *Engineering Design Methods: Strategies for Product Design*, London: Wiley.
- Pahl, G., Beitz, W., Feldhusen, J. and Grote, K. H. (2006) *Engineering Design: A Systematic Approach*, London: Springer.
- Tooley, M. and Dingle, L. (2004) *Higher National Engineering*, London: Newnes.
- Simmons, Colin H. Phelps Neil, Maguire Dennis E. (2012) *Manual of Engineering Drawing: Technical Product Specification and Documentation to British and International Standards* 4th Ed., Elsevier.
- McBeath, S. (2009). *Competition Car Data Logging*. Haynes.
- Segers,J. (2008). *Analysis Techniques for Racecar Data Acquisition*. SAE
- Smith,J. (2013). *Fundamentals of Motorsport Engineering*. Nelson Thornes.
- Templeman, G. (2008). *The Competition Car Data Logging Manual*. Speedpro.
- Tickoo,S. (2007). *EdgeCAM 11.0 for Manufacturers.* TBS

Date module first approved:	April 2015
Date of most recent revision:	April 2015

MODULE TITLE:	**Mathematics I**
MODULE NUMBER:	**ENGA4009**

1. MANAGEMENT DETAILS	
Module leader:	Garth Palin
Level:	4
No. of credits:	15
Mode of delivery:	face to face
Pre-requisites:	N/A
Co-requisites:	None
Barred combinations:	None
Other restrictions or requirements:	N/A
Timetable information:	Semester 1, 14 weeks

Programme/s in which this module may be taken	**Status on programme**
FdEng Motorsport Engineering- BW13	Core

2. MODULE AIMS

This module provides an introduction to the mathematical methods used in the study of engineering. Students learn the basic mathematical techniques needed to support the analytical modules in year one. This includes the study of basic algebraic methods, trigonometry, introductory vector mathematics, complex numbers, differential calculus and its applications to engineering problems.

3. LEARNING OUTCOMES

On successful completion of this module, students will be able to:	** Brookes Attribute developed*	*Other GAs developed, if applicable*
1. Solve simple, defined engineering problems by selecting a suitable approach	Academic Literacy	
2. Demonstrate the ability to apply techniques of differential and vector calculus to a range of engineering applications	Academic Literacy	
3. Demonstrate the ability to use trigonometry to solve triangles	Academic Literacy	
4. Model engineering problems in mathematical terms	Academic Literacy	Active Citizenship

*More details about the Brookes graduate attributes are available online at http://www.brookes.ac.uk/services/ocsld/sese/graduate_attributes.pdf.

UK-SPEC Learning Outcomes completed in this module:
The learning outcomes definition can be found, for example in the IET handbook of Learning outcomes: http://www.theiet.org/academics/accreditation/policy-guidance/handbook_lo.cfm

US1i	US2i					
	✓					
E1i	E2i	E3i	E4i			
		✓				
Di1	D2i	D3i	D4i	D5i		
✓						
S1i	S2i	S3i	S4i	S5i		
P1i	P2i	P3i	P4i	P5i	P6i	P7i

4. OUTLINE SYLLABUS

Algebra and Numbers: Numbers (e.g. whole, integers, surds, real), BODMAS, laws of indices, linear equations, quadratic equations (including completing the square), linear inequalities and regions, solutions of simultaneous equations in two variables (including a pair one linear equation & one quadratic equation), straight line graphs, arithmetic and geometric series. Introduction to complex numbers.

Trigonometry: radians, graphs (sine, cosine, tangent), and derivation of trigonometric identities, small angle approximations, solution of simple trigonometric equations. Treatment of hyperbolic functions (sinh(x), cosh(x) & tanh(x)) is optional.

Vectors: representation, unit vector, two & three dimensions, vector algebra, scalar & vector products and applications of vectors to engineering problems.

Differential Calculus: differentiate using first principles, gradient of polynomial functions, stationary & inflection points of algebraic functions, product & quotient rules, curve sketching (including quartic, logarithmic, exponential functions & hyperbolic functions (optional)), function notation f(t) for real values of t, differentiation of trigonometric, logarithmic & exponential functions, modelling simple growth and decay processes.

Further Topics (Optional, no assessment required):

- **Series Expansion**: use of the Taylor and the Maclaurin series expansion of functions of one variable.
- **Further Complex Numbers**: Cartesian, polar & exponential representation, complex conjugate, Argand diagram, De Moivre's theorem and application to engineering problems.

5. TEACHING LEARNING AND ASSESSMENT STRATEGY

This module is assessed 40% by coursework using open book tests and 60% by unseen exam which will give a combination of reflective learning and progression through the semester leading to the final summative assessment for the module. In completing this module students will have been given the opportunity to develop their academic literacy through attendance at lectures designed to cover the basic facts and present worked examples progressing from straightforward to challenging.

Their academic literacy will be developed further through the application of mathematical analysis utilising the skills developed for mechanical and electrical systems as well as other engineering examples. Students will develop their ability to analyse and solve problems involving systems and practice those skills when measuring and evaluating experimental test data.

Formative Assessment: All students will receive guidance in approaches to problem solving and formative assessment will be undertaken at regular intervals throughout the module, both with individual students and with the group as a whole.

Summative Assessment: Class Tests 40% & Exam 60%. Assessment of the learning outcomes for this module will be completed through class tests and examination based on application of relevant engineering mathematical theory to solution of problems. A minimum score of 30% must be achieved in every component of summative assessment in order to meet the subject specific regulations for the Foundation Degree.

6. LEARNING HOURS *(10 notional learning hours per credit)*

Scheduled learning and teaching activities *(contact hours)*	
Lectures (including exercise practice)	42 hours
Seminars	0 hours
Practical classes/workshops	0 hours
Tutorials	14 hours
Fieldwork/external visits	0 hours
Guided independent study	
Directed/independent study	64 hours
Preparation for assessments	30 hours
Placement/Study Abroad	
	0 hours
TOTAL:	**150 hours**

7. ASSESSMENT TASKS

7.1 Summative assignments (indicative)

Describe assessment tasks below	Word count/ length of exam	Learning outcomes assessed	Weighting	KIS category
Coursework				
2 Class tests	1 hour each	1,2,3,4	40 % (20% each)	1

Written examinations				
Exam	2 hours	1,2,3,4	60 %	2
Other				
N/A				

7.2 Opportunities for formative assessment and feedback
The class tests will consist of a series of exercises which will allow the student to assess how they have developed their mathematical abilities. Learning checks will take place at regular intervals throughout the module with formative feedback given to each student. Tutorial reviews will track the progress of individual students and identify areas of strength as well as actions for further development. In this way students will develop techniques for the analysis and solution of problems involving both mechanical and electric/electronic systems, while measuring and evaluating experimental test data will develop both academic literacy and digital and information literacy.

8. INDICATIVE READING LIST

- Bird, J.O. (2010) *Basic engineering mathematics*. 5th edn. Oxford; Burlington, MA: Newnes.
- Bird, J.O. (2010) *Engineering mathematics*. 6th edn. Oxford; Burlington, MA: Newnes.
- Bird, J.O. (2010) *Higher engineering mathematics*. 6th edn. Oxford: Newnes.
- Croft, T. and Davison, R. (2013) *Engineering Mathematics: a Foundation for Electronic, Electrical, Communications and Systems Engineers*. 4th ed. Pearson
- Croft, T. and Davison, R. (2006) *Foundation maths*. 4th edn. Harlow: Prentice Hall.
- James, G. (2010) *Modern engineering mathematics*. 4th edn. Harlow, England: Prentice Hall.
- Lee, S. (2008) *An introduction to mathematics for engineers : mechanics* [Book with CD]. London: Hodder Education.
- Stroud, K.A. and Booth, D.J. (2011) *Advanced engineering mathematics*. 5th edn. Basingstoke: Palgrave Macmillan.
- Stroud, K.A. and Booth, D.J. (2012) *Engineering mathematics*. 7th edn. Basingstoke; New York: Palgrave Macmillan.

Date module first approved:	2005
Date of most recent revision:	April 2015

MODULE TITLE:	**Engineering Science**
MODULE NUMBER:	**ENGA4010**

1. MANAGEMENT DETAILS	
Module leader:	Matthew Johnson
Level:	4
No. of credits:	15
Mode of delivery:	face to face
Pre-requisites:	N/A
Co-requisites:	N/A
Barred combinations:	None
Other restrictions or requirements:	None
Timetable information:	Semester 2, 14 weeks

Programme/s in which this module may be taken	**Status on programme**
FdEng Motorsport Engineering- BW13	Compulsory

2. MODULE AIMS

This module will provide students with the major Newtonian scientific principles which underpin the design and operation of engineering systems. It is a broad-based module, covering both static and dynamic mechanical systems and includes opportunities for the students to carry out practical experiments to confirm scientific theories. The module focuses on solving practical automotive problems, a vital skill to gain for any graduate engineer. The range of topics covers a broad range of disciplines including: Newtons Laws, Stress and Strain, Heat transfer, Fluid dynamics, Moments of inertia and other scientific areas that can be applied to all roles within the automotive industry that graduates may aim for.

3. LEARNING OUTCOMES

On successful completion of this module, students will be able to:	** Brookes Attribute developed*	*Other GAs developed, if applicable*
1. Determine distribution of shear force, bending moment and stress due to bending in simply supported beams;	Academic Literacy	
2. Determine the distribution of shear stress and angular deflection due to torsion in circular shafts;	Academic Literacy	
3. Determine the behaviour of dynamic and / or oscillating mechanical systems in which uniform acceleration or Simple Harmonic Motion is present;	Academic Literacy	
4. Describe the modes of heat transfer; Determine the rate of heat energy transfer rates in thermal systems;	Academic Literacy	
5. Describe the effect of Bernoulli principles; Calculate pressure variations with fluid flow.	Academic Literacy	

6. Describe lubricants used in race vehicles;	Academic Literacy	Active Citizenship
7. Apply relevant engineering science theory to mechanical systems;	Academic Literacy	
8. Analyse and solve problems involving mechanical systems;	Academic Literacy	
9. Measure and evaluate experimental test data.	Critical Self-Awareness and Personal Literacy	Active Citizenship

*More details about the Brookes graduate attributes are available online at http://www.brookes.ac.uk/services/ocsld/sese/graduate_attributes.pdf.

UK-SPEC Learning Outcomes completed in this module:
The learning outcomes definition can be found, for example in the IET handbook of Learning outcomes: http://www.theiet.org/academics/accreditation/policy-guidance/handbook_lo.cfm

US1i	US2i					
✓	✓					
E1i	E2i	E3i	E4i			
✓	✓	✓				
Di1	D2i	D3i	D4i	D5i		
S1i	S2i	S3i	S4i	S5i		
P1i	P2i	P3i	P4i	P5i	P6i	P7i
✓	✓					

4. OUTLINE SYLLABUS

- Newton's laws of motion. Uniform acceleration: distance/time graphs.
- Bending: shear force, bending moment and stress due to bending in simply supported beams subjected to concentrated and uniformly distributed loads; second moment of area;
- Torsion: shear stress, shear strain and angle of twisting of solid and hollow circular section shafts; combined stresses in drive shaft and suspension components;
- Equations of linear and angular acceleration. Mass moment of inertia and radius of gyration of rotating components, linear and angular motion and kinetic energy.
- Effects of friction; centrifugal and centripetal forces, skidding and overturning.
- Mechanical oscillations: simple harmonic motion, linear and transverse systems, qualitative description of the effects of forcing and damping;

- Modes of heat transfer: conduction, convection and radiation; Heat transfer, thermal conductivity, convection, Black body radiation, conduction and insulation; co-efficient of expansion and how these apply to vehicle design and construction;
- Viscosity: boundary layer formation, viscous drag, pressure loss in pipes, effect of temperature on viscosity; dynamic viscosity, power loss in plain journal and thrust bearings, Pascal's Law, Bernoulli principle and fluid dynamcs.
- Friction and lubrication: friction on horizontal and inclined planes, sliding and roller bearings, wear, embed-ability, wear resistance, Shaft joints and rose joints;
- Lubrication, additives, oxidation inhibitors, detergents, viscosity index improvers, anti-foam agents, pour point depressants and extreme pressure additives.

5. TEACHING LEARNING AND ASSESSMENT STRATEGY

Academic Literacy
Scientific principles are taught with self-assessment in a formative sense. The two assignments and end of year exam assess the students learning of the theory and calculations behind the topics.

Digital and Information Literacy
Students will expected to access not only books and web articles, but also eBooks and journals too, as the modules have a high emphasis on research. Our VLE provides great access to a range of journal databases and technical papers.

Critical Self-awareness and Personal Literacy
All students receive feedback for each assignment. They have a PDP form in which they record all constructive feedback and can write a reflective comment on how they will work on and overcome the criticism in the next assessment. They must also self-manage all of their assignments and therefore time accordingly.

The learning outcomes are met by teaching in the form of lectures, group discussions, practical sessions and problem solving sessions through discovery, challenge and evaluative thinking.
The module is primarily concerned with application of knowledge to applied scenarios, and experiential development of relevant techniques. Students learn about scientific principles in class and apply them to applications within the Motorsport sector.
The assessment regime is designed to test the development of understanding and learning in a rigorous way. Both assignments assess the application of knowledge to Motorsport problems. The examination also assesses the fundamental knowledge required for this process.

6. LEARNING HOURS *(10 notional learning hours per credit)*

Scheduled learning and teaching activities *(contact hours)*	
Lectures	35 hours
Seminars	7 hours
Practical classes/workshops	0 hours
Guided independent study	
Directed/independent study	100 hours
Preparation for assessments	8 hours
Placement/Study Abroad	
	0 hours
TOTAL:	**150 hours**

7. ASSESSMENT TASKS

7.1 Summative assignments (indicative)

Describe assessment tasks below…	Word count/ length of exam	Learning outcomes assessed	Weighting	KIS category
Coursework				
Coursework 1: Vehicle Application	1500	3,7,8,9	35%	1
Coursework 2: Vehicle Design	2000	1,2,3,4,7, 8	35%	1
Written examinations				
Exam	2 hours	2,3,4,5,6, 7,8	30%	2

7.2 Opportunities for formative assessment and feedback

Students will participate in lab sessions held within the science classroom and will be provided with feedback regarding their data collection and analysis. Mock exams will be used to prepare learners for the end of year exam. Ongoing case studies and question sets are used to gauge learners knowledge and understanding of each topic. All assignments are returned with formative written and verbal feedback to individuals and the group. This will enable the student to improve their work. Overall progress is monitored through formative feedback and regular meetings with the module leader and course tutor. An open door staffroom policy also gives the students the opportunity to discuss coursework and assessment with the module leader.

8. INDICATIVE READING LIST

Note: Series of course guidance booklets should be first consulted.

- Bolton W (2006) *Mechanical Science*. Blackwell Scientific.
- Callister, D. (2014) *Materials Science and Engineering*. John Wiley and Sons.9th ed
- Muncaster, R. (1993) *A-Level Physics.* Nelson Thornes 4th ed
- Tooley M, Dingle L (2004) *Higher National Engineering*. Butterworth-Heinemann.
- Twigg P (1999) *Science for Motor Vehicle Engineers*. Arnold.

Date module first approved:	2010
Date of most recent revision:	March 2015

MODULE TITLE:	**Composites and Materials Technology**
MODULE NUMBER:	**ENGA4008**

1. MANAGEMENT DETAILS	
Module leader:	Marcus James
Level:	4
No. of credits:	15
Mode of delivery:	face to face
Pre-requisites:	N/A
Co-requisites:	N/A
Barred combinations:	None
Other restrictions or requirements:	None
Timetable information:	Semester 1, 14 weeks

Programme/s in which this module may be taken	**Status on programme**
FdEng Motorsport Engineering- BW13	Compulsory

2. MODULE AIMS

This module will provide students with the opportunity to learn the theory and practice of the properties and uses of materials used in the motorsport industry. This will be largely related to the selection, treatment and manufacture of materials used for individual parts and systems. The module will provide students with a detailed knowledge of the properties and the processes of a range of materials commonly used as well as the concepts of stress and strain. This module will include an extracurricular composites practical in semester 2.

3. LEARNING OUTCOMES

On successful completion of this module, students will be able to:	*Brookes Attribute developed*	*Other GAs developed, if applicable*
1. Define and evaluate the advantages & disadvantages of different materials.	Academic Literacy	Research Literacy, Critical Self-Awareness and Personal Literacy
2. Define the advantages and disadvantages of Thermosetting and Thermoplastic composites.	Academic Literacy	Research Literacy
3. Present a report on the tools and processes used in materials testing.	Research Literacy	Academic Literacy , Active Citizenship
4. Describe the materials used in composite lay-up.	Academic Literacy	
5. Determine what materials & processes are appropriate to particular technical requirements.	Academic Literacy	Critical Self-Awareness and Personal Literacy
6. Understand the requirements for safe working, handling & storage of different materials. Exercise appropriate ethical judgment of environmental concerns and how safety can be ensured.	Critical Self-Awareness and Personal Literacy	Active Citizenship
7. Understand the function, materials and manufacturing processes involved with automotive components and systems.	Academic Literacy	Critical Self-Awareness and Personal Literacy

UK-SPEC Learning Outcomes completed in this module:

The learning outcomes definition can be found, for example in the IET handbook of Learning outcomes: http://www.theiet.org/academics/accreditation/policy-guidance/handbook_lo.cfm

US1i	US2i					
✓						
E1i	E2i	E3i	E4i			
	✓					
Di1	D2i	D3i	D4i	D5i		
				✓		
S1i	S2i	S3i	S4i	S5i		
✓		✓	✓			
P1i	P2i	P3i	P4i	P5i	P6i	P7i
✓	✓	✓		✓	✓	

4. OUTLINE SYLLABUS

Composites

- Benefits of composite materials
- Basic components of composite materials
- Basic processes used in laying up composite material
- Safe working with composite materials.
- Producing a composite component

Materials

- Structural composition and properties of materials i.e. series of alloys and steel.
- Manufacturing processes used in the production of automotive parts i.e. cast, forged, billet, extrusion, cold rolling, laser and water cutting, printing and prototyping.
- Heat treatments and surface treatments, including plating, anodising, chromate, chemical treating and powder coating.
- Practical testing and analysis of materials – stress, strain, fatigue, torsion, elasticity, shear, double shear, thermal expansion, compression, tension (tensile) and degradation (oxidisation, corrosion, thermal, water, UV)
- Mechanical processing i.e. effect on structure and properties by a range of processes such as mechanical working, joining, welding and adhesives.

5. TEACHING LEARNING AND ASSESSMENT STRATEGY

Scientific principles are taught with self-assessment in a formative sense. The two assignments and end of year exam assess the students learning of the theory and calculations behind the topics.

This module studies the characteristics of different materials whilst calculations are carried out to analyse the performance of such materials and how they affect designs and technologies incorporated in modern day race cars.
All students receive feedback for each assignment. They have a PDP form in which they record all constructive feedback and can write a reflective comment on how they will work on and overcome the criticism in the next assessment. They must also self-manage all of their assignments and therefore time accordingly.
Students will be expected to access not only books and web articles, but also eBooks and journals too, as the modules have a high emphasis on research. Our VLE provides great access to a range of journal databases and technical papers.
Practical testing allows students to evaluate the performance curves of different materials and with case studies for comparison, make an evaluation of a materials suitability for motorsport applications.
Learning outcomes are met by teaching in the form of lectures and supported by group work, discussions, practical testing and completing exercises.

Students will undertake a practical seminar in composites mould and product manufacture and will also have various production methods explained and demonstrated to them including vacuum bagging and the use of Fibre Infusion Resin Silicon Technology. Practical tests will be carried out with different composites and core material options. The use of materials including gel coatings, release agents, catalyst and resins will also be studied to ensure students learn the purposes for each and how they can be applied in different ways based on the varying manufacture specifications and goals.

6. LEARNING HOURS *(10 notional learning hours per credit)*	
Scheduled learning and teaching activities *(contact hours)*	
Lectures	14 hours
Seminars	7 hours
Practical classes/workshops	29 hours
Tutorials	0 hours
Fieldwork/external visits	0 hours
Guided independent study	
Directed/independent study	50 hours
Preparation for assessments	50 hours
Placement/ Study Abroad	
	0 hours
TOTAL:	**150 hours**

7. ASSESSMENT TASKS

7.1 Summative assignments (indicative)				
Describe assessment tasks below…	Word count/ length of exam	Learning outcomes assessed	Weighting	KIS category
Coursework				
Coursework 1: Materials Case Study	4000	1,4,5,6,7	50%	1
Written examinations				
Exam	2 hours	1,2,3 5,6,7	50 %	2
Other				
N/A				

7.2 Opportunities for formative assessment and feedback
Students are given both verbal and written feedback individually and for the group after each assessment. The subject team operate an open door policy so that students can gain support and feedback when required. A module handbook is provided that includes case study questions on the topics to assess learners knowledge and understanding prior to summative assessment. Presentations are also included to assess learner's knowledge. Practical seminars of material testing will be closely monitored by the module leader. The composites materials block will include formative assessment throughout initial manufacture of a component being produced.

8. INDICATIVE READING LIST

- Barbero, E. (2010) *Introduction to Composite Materials Design.* Taylor and Francis
- Forbes D Aird. (2006) *Fiberglass and Composite Materials*. HP Books
- Hull, D. and Clyne, T. (2010) *An Introduction to Composite Materials.* 2nd Ed. Cambridge: Solid State Science. Cambridge: University Press
- McBeath, S. (2009) *Competition Car Composites: A Practical Guide*. Haynes Competition Car Series
- Bolton, W. (2006) *Engineering science*. 5th Ed. Newnes.
- Hearn, E.J. (1997) *Mechanics of materials 2: Mechanics of Elastic and Plastic Deformation of Solids and Structural Materials.* 3rd Ed. Butterworth Heinemann.
- Ashby, M.F. (2011) *Materials Selection in Mechanical Design.* 4th ed. Butterworth-Heinemann

Date module first approved:	2005
Date of most recent revision:	April 2015

MODULE TITLE:	**Engine Technology**
MODULE NUMBER:	**ENGA4012**
1. MANAGEMENT DETAILS	
Module leader:	Marcus James
Level:	4
No. of credits:	15
Mode of delivery:	Face to Face
Pre-requisites:	N/A
Co-requisites:	N/A
Barred combinations:	None
Other restrictions or requirements:	None
Timetable information:	Semester 2, 14 weeks

Programme/s in which this module may be taken	**Status on programme**
FdEng Motorsport Engineering - BW13	Compulsory

2. MODULE AIMS

Throughout this module you will apply scientific formula to a range of real world problems to gain an understanding of how a theoretical engine works. The logic applied to the calculations will cross over with other modules as well as setting you up for your future career. You will also focus on engine operating characteristics and investigate how each part of an engine works to produce an efficient power output, assisted by the use of the rolling road. You will carry out practical tasks which include stripping an engine and working to improve the air flow through a cylinder head using a head flow bench. The practical and theoretical skills acquired through this module will be applicable in a range of technology or engineering related careers.

3. LEARNING OUTCOMES

On successful completion of this module, students will be able to:	**Brookes Attribute developed*	*Other GAs developed, if applicable*
1. Analyse the effects of altering engine design factors;	Academic Literacy	
2. Calculate torque, power, thermal efficiency, volumetric efficiency, MEP and specific fuel consumption;	Academic Literacy	
3. Calculate pressure, volume and temperature during the engine cycle using Thermodynamic equations.	Academic Literacy	
4. Carry out a dynamometer test with analysis of the results.	Active Citizenship	Academic Literacy Digital and Information Literacy
5. Carry out a head flow test with analysis of results.	Active Citizenship	Academic Literacy Research Literacy

		Critical Self-Awareness and Personal Literacy
6. Specify components and systems for a given application including lubrication.	Active Citizenship	Academic Literacy Research Literacy

*More details about the Brookes graduate attributes are available online at http://www.brookes.ac.uk/services/ocsld/sese/graduate_attributes.pdf.

UK-SPEC Learning Outcomes completed in this module:
The learning outcomes definition can be found, for example in the IET handbook of Learning outcomes: http://www.theiet.org/academics/accreditation/policy-guidance/handbook_lo.cfm

US1i	US2i					
✓	✓					
E1i	E2i	E3i	E4i			
✓	✓					
Di1	D2i	D3i	D4i	D5i		
	✓		✓			
S1i	S2i	S3i	S4i	S5i		
P1i	P2i	P3i	P4i	P5i	P6i	P7i
✓					✓	

4. OUTLINE SYLLABUS

Engine Design and Performance Fundamentals:
Performance curves: calculate performance curves for SI, CI and pressure charged engines, carry out an engine test at various engine speeds and produce a critical evaluation of air/fuel ratio, torque, power, fuel consumption, explain the significance of the standards used to measure engine power including, DIN, SAE, EEC, apply the knowledge of engine performance curves and design to the selection of appropriate power modules for specific tasks.

Application of the following Engine Performance Theory and Calculations:

- Torque
- Power
- Mechanical efficiency
- Thermal efficiency
- Volumetric efficiency,
- Mean effective pressure,
- Specific fuel consumption

Principles and Operation of Engine Management Systems including:

- Ignition timing
- Fuelling control

- Sensors and actuators
- Theory of mapping and look-up tables

Engine Design Theory and Calculations for the following components:

- Carburettors and Throttle Bodies
- Inlet System
- Exhaust system
- Turbochargers
- Superchargers

Basic Thermodynamic Theory and Calculations including:

- P-V and P-Theta graphs
- Thermal Efficiency
- Pressure, Volume and Temperature during engine cycles
- Cycle Heat Input
- Net Work Output
- Gas Laws

5. TEACHING LEARNING AND ASSESSMENT STRATEGY

Academic Literacy
Calculations and engine analysis form the basis of the module to include teaching and the assessment, whilst the practical session moves that further with the use of the head flow bench. Students also study a range of systems and new technology that is integrated within the engine system.

Research Literacy
Students must analyse and put into practise the research gained for cylinder head flow performance. The wealth of different opinions and principles must be evaluated and selected according to the aims of the assignment task containing the head flow practical tasks.

Critical awareness and Personal Literacy
Students are actively encouraged to share their thoughts and ideas on the direction and new focus coming into engine technology as this is a fast moving technology currently.

Digital and Information Literacy
Students will expected to access not only books and web articles, but also eBooks and journals too, as the modules have a high emphasis on research. Our VLE provides great access to a range of journal databases and technical papers.

6. LEARNING HOURS *(10 notional learning hours per credit)*

Scheduled learning and teaching activities *(contact hours)*	
Lectures	56 hours
Seminars	4 hours
Practical classes/workshops	18 hours
Guided independent study	
Directed/independent study	36 hours
Preparation for assessments	36 hours
Placement/ Study Abroad	
	0 hours
TOTAL:	**150 hours**

7. ASSESSMENT TASKS

7.1 Summative assignments				
Describe assessment tasks below…	Word count/ length of exam	Learning outcomes assessed	Weighting	KIS category
Coursework (indicative)				
Coursework 1: Assignment	5000 words	1,2,4,6	50%	1
Coursework 2: Viva	20 minutes	1,5,6	20%	3
Written examinations				
Exam	2 hours	2,3	30%	2
Other				
N/A				

7.2 Opportunities for formative assessment and feedback

Students receive feedback throughout each topic with the use of case studies and questions sets testing their understanding and knowledge. Students also participate in a series of rolling road practical sessions with feedback provided on the procedures used during the practical and then the students collation and appropriate analysis of the data collected. Self-study work is collected and marked at the end of each significant topic. End of year mock exam allows students to gain feedback for exam technique and performance. All assignments are returned with formative written and verbal feedback to individuals and the group. This will enable the student to improve their work. Overall progress is monitored through formative feedback and regular meetings with the module leader and course tutor. An open door staffroom policy also gives the students the opportunity to discuss coursework and assessment with the module leader.

8. INDICATIVE READING LIST

- Bell, A. (2006) *Four Stroke Performance tuning*. Haynes.
- Bell, A. (2002) *Forced Induction Tuning.* Haynes
- Banish, G (2007) *Engine Management: Advanced tuning* S-A-Design
- Burgess, P. (2013). *How to build, modify and power tune cylinder heads.* Veloce
- Heisler, Heinz (2002) *Advanced Engine Technology*. Butterworth-Heinemann
- Yunus et al, (2007) *Thermodynamics (SI Units):An engineering Approach*. McGraw-Hill.
- Zammit,S (1987) *Motor Vehicle Engineering Science.* Longman

Date module first approved:	2005
Date of most recent revision:	April 2015

LEVEL 5 MODULES

MODULE TITLE:	**Work Based Project**
MODULE NUMBER:	**ENGA5017**

1. MANAGEMENT DETAILS	
Module leader:	Josh Smith
Level:	5
No. of credits:	30
Mode of delivery:	Blended Learning
Pre-requisites:	ENGA4007
Co-requisites:	N/A
Barred combinations:	None
Other restrictions or requirements:	None
Timetable information:	Semesters 1 & 2, 28 weeks

Programme/s in which this module may be taken	**Status on programme**
FdEng Motorsport Engineering-BW13	Compulsory

2. MODULE AIMS

This module is intended to enable students to develop their own skills in designing, researching, executing, analysing and communicating a motorsport engineering project. The topics chosen will, wherever possible, relate to real life problems and will simulate situations likely to be encountered in a working environment. The aims and objectives of the course are underpinned by the need to develop rational engineering approaches. The project unit offers students the opportunity to further enhance the skills developed in Level 4 and to demonstrate the practical application of those skills. The element of time and self-management is vital in this module along with thorough research of current theories, available design ideas and resource management. These skills are important for ensuring that a graduate can progress into industry with the ability to complete projects and tasks in a timely and autonomous manner.

3. LEARNING OUTCOMES

On successful completion of this module, students will be able to:	** Brookes Attribute developed*	*Other GAs developed, if applicable*
1. Identify those tasks or operations that require the depth of research and investigation that justify selection to be run as a project and, through negotiation, agree suitable specifications and procedure	Research Literacy	Academic Literacy Active Citizenship

2. Show that they have grasped the need to implement the project within agreed procedures and to specification	Critical Self-Awareness and Personal Literacy	Active Citizenship
3. Self-manage and evaluate their work	Critical Self-Awareness and Personal Literacy	Active Citizenship
4. Undertake and critically analyse literature surveys for project using online and paper-based resources	Research Literacy	Digital and Information Literacy
5. Describe the purpose and rational for each section of an engineering report based on a generalised template but tailored to meet the professional requirements of the company in which the project is being undertaken so that they are able to produce a project report, including details of project management	Academic Literacy	Research Literacy
6. Identify and use the tools, skills and techniques necessary to give a presentation of the project outcomes to an audience using audio visual techniques	Digital and Information Literacy	Research Literacy

*More details about the Brookes graduate attributes are available online at http://www.brookes.ac.uk/services/ocsld/sese/graduate_attributes.pdf.

UK-SPEC Learning Outcomes completed in this module:

The learning outcomes definition can be found, for example in the IET handbook of Learning outcomes: http://www.theiet.org/academics/accreditation/policy-guidance/handbook_lo.cfm

US1i	US2i					
E1i	E2i	E3i	E4i			
✓	✓	✓	✓			
Di1	D2i	D3i	D4i	D5i		
✓	✓	✓	✓	✓		
S1i	S2i	S3i	S4i	S5i		
✓	✓	✓	✓	✓		
P1i	P2i	P3i	P4i	P5i	P6i	P7i
✓	✓	✓	✓	✓	✓	✓

4. OUTLINE SYLLABUS

Select a Project

- Process of project selection: formulate project plans, appraise the feasibility of the projects and carry out an initial critical analysis of the outline specification, select chosen project option, initiate a project log-book/diary, estimate costs and resource implications, identify goals and limitations. Produce a relevant project title with underpinning aims and objectives that are SMART
- Project specifications: identify and record the technical and non-technical requirements relevant to the appropriate level of study and chosen project type.
- Procedures: planning and monitoring methods, methods of working, lines of communication, targets and aims.

Implement the project

- Implement: proper use of resources, work within agreed time scale, use of appropriate techniques for generating solutions, maintaining and adapting project plan where appropriate, maintaining all records of development/progress, validating results.
- Record: maintain log-book/diary entries, prepare and collate developmental work.

Evaluate

- Evaluation technique: appraisal of the feasibility/effectiveness of the project solution and a critical analysis against the project specification and planned procedures, use of graphs, statistics, Gantt charts, sequencing, scheduling, critical path methods, networking, application of PERT, using computer software packages where appropriate.

Present project outcome

- Record of procedures and results: log-book/diary record of all events, record of developmental work, working records of planning and monitoring procedures, relevant data and results
- Present: formal project report, use of appropriate media and methods, presentation to known audiences and unknown audience

5. TEACHING LEARNING AND ASSESSMENT STRATEGY

Students completing this unit will have been given the opportunity to learn from a combination of formal tutor input, on line materials and experience gathered in Work Based Learning and other L4 and L5 modules. Students will need to find a suitable academic supervisor (list can be found on VLE) and will need to identify a work based supervisor for projects undertaken at a work environment. The project must be agreed by both supervisors. The project will be divided into the following phases all of which will be assessed:

- Plan
- Interim
- Final report and Presentation

Suitable milestones will be agreed for these major points, requiring demonstrations, presentations and reports aimed at different audiences. Formative feedback will be provided by the advisor(s) at each point.

The graduate attributes are met in the following way:

Academic literacy

Students will use a range of techniques to initiate and undertake a critical analysis of information, and to propose and implement solutions arising from this analysis.

Research literacy

Tutorials will provide students with skills to manage the project and build project skills. The project requires the students to self-manage and plan this double module with a large focus on research,

analysis, testing and evaluating. It is assessed at 3 stages across the year with a combination of written reports and presentations.

Critical self-awareness and personal literacy
Students need to manage and self-evaluate their work during the duration of the project. Furthermore they will present the project to a live audience using audio visual techniques. Their work must be effectively communicated in a variety of formats to both technical and non-technical audiences.

Digital and information literacy
Students will use a range of techniques to initiate and undertake a critical analysis of information, and to propose and implement solutions arising from this analysis. Furthermore they will use online resources to undertake their theoretical research and use appropriate technologies to present the outcomes of the project.

Active citizenship
During the project, students will need to maintain a major practical, possibly work based project. For this they will need to work as part of a team and possibly work in a client oriented posture.

In addition to meeting the requirements of Graduate Attributes, the module must contribute to the learning outcomes matrix defined in UKSPEC by the IET and IMechE. A table showing this contribution is provided at the end of section three.

6. LEARNING HOURS *(10 notional learning hours per credit)*	
Scheduled learning and teaching activities *(contact hours)*	
Lectures	0 hours
Seminars	0 hours
Practical classes/workshops	0 hours
Tutorials	10 hours
Fieldwork/external visits	10 hours
Guided independent study	
Directed/independent study	250 hours
Preparation for assessments	30 hours
Placement/Study Abroad	
	0 hours
TOTAL:	**300 hours**

7. ASSESSMENT TASKS

7.1 Summative assignments (indicative)

Describe assessment tasks below…	Word count/ length of exam	Learning outcomes assessed	Weighting	KIS category
Coursework				

1.Presentation: Project Plan	15 minutes + questioning	1,2,6	10%	3
2. Project Interim Report	4000	1,2,3,4,5	20%	1
3. Project Final Report	8,000	1,2,3,4,5	50%	1
4. Presentation: Final Report	15 minutes + questioning	1,2,3,4,5, 6	20%	3
Written examinations				
N/A				
Other				
N/A				

7.2 Opportunities for formative assessment and feedback

Throughout the execution of the entire project students will receive feedback and advice from the project supervisors and from technical staff within the faculty who will advise on computational and workshop facilities. In addition all assessments before the final report will receive feedback so that students can improve their written report and presentation. Log books are checked in tutorial sessions to track students progress by the course tutor. All assignments are returned with formative written and verbal feedback to individuals and the group. This will enable the student to improve their work. Overall progress is monitored through formative feedback and regular meetings with the module leader and course tutor. An open door staffroom policy also gives the students the opportunity to discuss coursework and assessment with the module leader.

8. INDICATIVE READING LIST

- Allison, B. (2004). *The Student's Guide to Preparing Dissertations and Theses*. London: Kogan Page.
- Cryer, P. (2006) *The Research Student's Guide to Succ*ess. 3rd Ed. Open University Press.
- Lewis, J. (2010) *Project Planning Scheduling and Control*. McGraw-Hill Professional
- Lock, D. (2007) *Project Management*, 9th Edition Hampshire: Gower.
- Smith, N.J. (2008) *Engineering Project Management*,3rd Edition Oxford: Blackwell
- Lockyear, K & Gordon, J. (2005) *Project Management and Project Network Techniques*, 7th Edition, Harlow: FT Prentice Hall/Pearson Education
- Lester, A. (2013) *Project Management, Planning and Control*, 6th Edition. Oxford: Butterworth Heinemann

Relevant Industry Specific Journals

Date module first approved:	2005
Date of most recent revision:	April 2015

MODULE TITLE:	**Vehicle Dynamics and Performance Engineering**
MODULE NUMBER:	**ENGA5010**

1. MANAGEMENT DETAILS	
Module leader:	Josh Smith
Level:	5
No. of credits:	30
Mode of delivery:	Face to Face
Pre-requisites:	ENGA4011, ENGA4012
Co-requisites:	N/A
Barred combinations:	None
Other restrictions or requirements:	None
Timetable information:	Semesters 1 & 2, 28 weeks

Programme/s in which this module may be taken	**Status on programme**
FdEng Motorsport Technology- BW13	Compulsory

2. MODULE AIMS

This double module enables the student to acquire an advanced level of knowledge, design requirements, reasoning ability and practical skills for the operation, testing, diagnostics and adjustments of the main performance car chassis and powertrain systems. This is done through a combination of classroom, simulation and practical activities in small groups.

It will also enable the student to apply a range of skills and knowledge gained across the course to the performance vehicle as a whole, especially in the context of competition usage with the main focus being upon race car engineering and eligibility.

3. LEARNING OUTCOMES

On successful completion of this module, students will be able to:	** Brookes Attribute developed*	*Other GAs developed, if applicable*
1. Analyse the operation and interrelationship of the main vehicle chassis systems – steering, suspension, wheels and tyres – for performance vehicles both theoretically and practically;	Academic literacy	
2. Carry out calculations that analyse and reflect a full understanding under varying conditions of the main vehicle chassis systems – steering and suspension angles, suspension rates and tyre performance.	Academic literacy	

3. Record and analyse vehicle test data	Digital and information literacy	Active Citizenship
4. Analyse the operation and interrelationship of the main vehicle powertrain systems – transmission and braking – for performance vehicles both theoretically and practically;	Academic literacy	
5. Carry out calculations that analyse and reflect a full understanding under varying conditions of the main vehicle powertrain systems – torque, gear ratios, car performance and braking power.	Academic literacy	
6. Demonstrate knowledge of available types of lubrication systems	Research literacy	
7. Describe and discuss the ergonomic and human factors related to performance car design and eligibility;	Active citizenship	
8. Understand and evaluate FIA/MSA rules and competition regulations against a vehicle, carry out checks to ensure this;	Active citizenship	
9. Write a vehicle maintenance schedule and life chart, carry out tests to evaluate condition and suitability;	Academic literacy	
10. Understand and evaluate fasteners and fixings used in the Motorsport industry	Research literacy	
11. Produce, use and analyse drawings of chassis and powertrain system layouts	Digital and information literacy	Academic literacy
12. Carry out a full chassis set up of a performance vehicle in the workshop	Critical self-awareness and personal literacy	Active Citizenship

*More details about the Brookes graduate attributes are available online at http://www.brookes.ac.uk/services/ocsld/sese/graduate_attributes.pdf.

UK-SPEC Learning Outcomes completed in this module:

The learning outcomes definition can be found, for example in the IET handbook of Learning outcomes: http://www.theiet.org/academics/accreditation/policy-guidance/handbook_lo.cfm

US1i	US2i					
✓	✓					
E1i	E2i	E3i	E4i			
✓	✓	✓	✓			

Di1	D2i	D3i	D4i	D5i		
			✓	✓		
S1i	S2i	S3i	S4i	S5i		
			✓			
P1i	P2i	P3i	P4i	P5i	P6i	P7i
✓	✓			✓		

4. OUTLINE SYLLABUS

Steering and suspension systems and Design

- Principles and layout of steering and suspension systems: suspension linkages, suspension mediums and dampers. Effects of equal / unequal parallel and non-parallel links. Effects of long short arm suspension links. Effects of track and wheel base dimensions.
- Measure and calculate castor, camber, SAI, wheel alignment, bump steer, Ackermann toe-out on turns and roll centres. Bump, rebound, heave, pitch, roll, and yaw. SAE vehicle annotation system. Oversteer and understeer. Wheel bearings, hubs, rack and pinion, steering column, steering wheel fittings. Suspension rate calculations. Weight, Mass and load transfers under varying conditions. Steering and suspension set up to maximise vehicle performance.
- Analyse the how various system designs and adjustments within these designs impact on the vehicle dynamics under varying conditions.

Wheels and tyres.

- Design characteristics and features of competition wheels and tyres: steel and cast aluminium alloy wheels & magnesium wheels. Stud, screw and centre fitting wheels/hubs. Diagonal, radial and bias belted tyres. Tyre markings and convention marks – size, speed rating, aspect ratio, and other fitting markings. Wheel and tyre safety and security. SAE tyre annotation system.
- Reasoning for given tyre compounds and resulting traction. Temperature. Tyre dynamics under load and how this affects the main chassis systems and performance. Slip angles
- Analyse how various wheels and tyres impact on vehicle dynamics under varying loads and conditions.

Ergonomics:

- Normal distribution of human proportions.
- Concepts of: sight, strength, vision and hearing. Norms and limits.
- Factors in race/rally car design appropriate to car/driver interface, including: seats, instruments, clutch, brakes, steering.

Weight transfer:

- Calculations for FWD and RWD layouts. Calculations for skidding and overturning. Tyre road interface.
- Engine and gearbox layout: FWD and RWD, mid-engined, longitudinal and transverse positions.
- Wheel and tyres: wheel and tyre construction, tyre tread patterns, typical values for MU torque and TE calculations.

Braking systems:

- Hydraulic and mechanical, disc, drum, brake balance.
- Brake Components: Multi-pot callipers, rented and drilled discs, steel and carbon materials.
- Brake force calculations: self-servo action.

Suspension and Steering layouts:
In board and out board set-ups, quick racks steering wheel location. Steering angles: drawings and calculations for steering angles including caster, camber, SAI, roll centre, roll axis, anti-squat, anti-dive.

The framework for vehicle regulations control and Scrutineering.
The FIA, MSA or other governing body rules for one class of racing or rallying.

Braking

- Layout characteristics, operation and design analysis of, single-seater formula, GT and rally car braking systems: cross-drilled and vented discs, multi-piston callipers, braking force and pressure, steel and carbon-carbon. Brake fluid and lines and calculate pressure distribution. How various designs can impact on the performance of a given vehicle.
- Analyse and carry out calculations related to braking materials (Disc's, pads), stopping distances, application forces, pressures, energy dissipated.

Engine/Transmission/drivelines

- Layout and operation of competition vehicle transmission systems: gearbox, final drive, FWD, RWD, trans-axle, drive shafts, propeller shaft, Hotchkiss drive. Flywheel/ Clutch: single and multi-plate designs. Friction materials, calculations and effects on forces, pressure, energy, toque transferred. Stressed and non-stressed members.
- Choice of transmission system for given class regulations, and its effect on vehicle performance. Tuning the engine to transmission for various performance applications. Calculate Power, torque gearing for tractive effort, gradients, acceleration, top speed, mechanical efficiencies & how the performance of the power train can be maximised, saw tooth charts. Differentials: semi, lock, electronic and mechanical.

Performance Engineering

- Oil systems – dry sump, baffled, oil accumulator, coolers and temperatures and pressures
- Fixings and fasteners, materials
- Eligibility and scrutineering

5. TEACHING LEARNING AND ASSESSMENT STRATEGY

Academic Literacy
This module studies the characteristics and behaviour of chassis handling and powertrain performance whilst calculations are carried out to analyse the performance of such designs and technologies incorporated in modern day race cars.
Tasks carried out in the workshop, on race days, taught sessions and the assessments require students to have a sound knowledge and understanding of the topics whilst being able to apply them to real life situations to solve problems and improve performance.

Research Literacy
Students must carry out a range of chassis adjustments to the vehicles in the college workshop. They must be checked, analysed and adjusted accordingly.
Students must read, interpret and analyse MSA and series regulations in order to complete their assessment tasks based upon making a car legal for a race series.
Students must carry out a range of transmission and braking adjustments to the vehicles in the college workshop. They must also be checked, analysed and adjusted accordingly.

Active Citizenship

This module has an emphasis on how the motorsport industry works across the world, discussing UK and global motorsport organisations, series and legislation. The assessments for the module also ensure students have an understanding of the motorsport structure globally.

Digital and Information Literacy
Students are required to use software in order to analyse car performance. This forms a key part of their assessment and evidence of understanding.
Students will be expected to read and evaluate rules and regulations relevant to their chosen car used in a race series.
Students will be expected to access not only books and web articles, but also eBooks and journals too, as the modules have a high emphasis on research. Our VLE provides great access to a range of journal databases and technical papers in the topics within this module.

Critical self-awareness and personal literacy
This module requires students to learn theory and practise this in the workshop and to finally write up their findings in a report on Vehicle Dynamics, Powertrain and Performance Engineering. All principles and technology is current and relevant to a range of different disciplines. The principles and theories learnt will also be carried out collectively in the workshop where teamwork is required. Students have to work together in order to carry out practical tasks in the workshop which are used to generate assignments, this also involves analysing data from race events collectively in the team debrief.

6. LEARNING HOURS *(10 notional learning hours per credit)*	
Scheduled learning and teaching activities *(contact hours)*	
Lectures	84 hours
Seminars	5 hours
Practical classes/workshops	50 hours
Guided independent study	
Directed/independent study	100 hours
Preparation for assessments	61 hours
Placement/ Study Abroad	
	0 hours
TOTAL:	**300 hours**

7. ASSESSMENT TASKS

7.1 Summative assignments (indicative)

Describe assessment tasks below…	Word count/ length of exam	Learning outcomes assessed	Weighting	KIS category
Coursework				
Coursework 1: Assignment 1 Chassis	5000	1-3,7-12	25%	1
Coursework 2: Assignment 2 Powertrain	5000	3-5,8-11	25%	1
Written examinations				

Online class tests	10x short online VLE quizzes	6-8,10	50% (5% each)	3
Other				
N/A				

7.2 Opportunities for formative assessment and feedback

Students are given verbal and written feedback after each assessment. Overall progress is monitored through formative feedback and regular meetings with the module leader and course tutor. An open door staffroom policy also gives students the opportunity to discuss coursework and assessment with the module leader. Workshop tasks and student presentations in lessons provide learners with continuous feedback about both their theoretical and practical performance on the module which can also be applied within other modules across the course.

8. INDICATIVE READING LIST

- Bell, A. (2006) *Four Stroke Performance Tuning*. Haynes.
- Staniforth, A, (2006), *Competition Car Suspension: Design*, Construction and Tuning Haynes
- Milliken W, Milliken D. (2003) *Race Car Vehicle Dynamics*. SAE
- Seward, D. (2014). *Race Car Design.* Palgrave Macmillan
- Smith, C. (1998), *Engineer to Win.* Aero Publishers Inc.
- Smith, C. (2004), *Tune To Win*. Aero Publishers Inc.
- Smith, C. (1991), *Nuts. Bolts. Fasteners and Plumbing*. Aero Publishers Inc.
- Smith, C. (1987), *Prepare to Win.* Aero Publishers Inc.
- Smith, J. (2013) *Fundamentals of Motorsport Engineering*. Nelson Thornes.

Date module first approved:	2010
Date of most recent revision:	April 2015

MODULE TITLE:	**Computer Aided Engineering**
MODULE NUMBER:	**ENGA5012**

1. MANAGEMENT DETAILS	
Module leader:	Josh Smith
Level:	5
No. of credits:	15
Mode of delivery:	Face to Face
Pre-requisites:	ENGA4011, ENGA4008
Co-requisites:	N/A
Barred combinations:	None
Other restrictions or requirements:	None
Timetable information:	Semester 1,14 weeks

Programme/s in which this module may be taken	**Status on programme**
FdEng Motorsport Engineering- BW13	Compulsory

2. MODULE AIMS

This module enables students to design and build small mechanical engineering products and/or assemblies using computer aided design. The module also makes use of Finite Element Analysis (FEA), Computational Fluid Dynamics (CFD) and Dynamic analysis of Mechanical systems to solve engineering problems bringing together engineering knowledge learnt in earlier parts of the course. Students learn to express their design ideas in 3D CAD, use CAE to optimise the design and then prepare detailed drawings from which final parts could be made.

3. LEARNING OUTCOMES

On successful completion of this module, students will be able to:	** Brookes Attribute developed*	*Other GAs developed, if applicable*	*Taught, Practiced, Assessed*
1. Apply engineering principles and analytical techniques in the design process.	Academic Literacy	Research Literacy, Critical Self-Awareness and Personal Literacy	T, P, A
2. Create a virtual prototype design of a part using CAE tools	Research Literacy	Digital and Information Literacy	T, P, A
3. Describe a range of finite element types and select those appropriate for modelling a specific design.	Academic Literacy	Research Literacy	T, P, A
4. Build and mesh finite element models	Digital and Information Literacy	Active Citizenship	T, P, A

5. Load, constrain and critically review FEA results	Critical Self-Awareness and Personal Literacy	Academic Literacy	T, P, A
6. Work with others to produce a design prototype	Active Citizenship	Research Literacy, Critical Self-Awareness and Personal Literacy	T, P, A
7. Give a well-structured group presentation	Critical Self-Awareness and Personal Literacy	Digital and Information Literacy, Active Citizenship	P, A

*More details about the Brookes graduate attributes are available online at http://www.brookes.ac.uk/services/ocsld/sese/graduate_attributes.pdf.

UK-SPEC Learning Outcomes completed in this module:

The learning outcomes definition can be found, for example in the IET handbook of Learning outcomes: http://www.theiet.org/academics/accreditation/policy-guidance/handbook_lo.cfm

US1i	US2i					
✓	✓					
E1i	E2i	E3i	E4i			
	✓	✓	✓			
Di1	D2i	D3i	D4i	D5i		
✓	✓	✓	✓	✓		
S1i	S2i	S3i	S4i	S5i		
✓		✓				
P1i	P2i	P3i	P4i	P5i	P6i	P7i
✓			✓	✓		

4. OUTLINE SYLLABUS

The content will be delivered in the context of small group work by undertaking a design problem from conception to completion. This will include computer aided analysis, manufacturing drawings and CNC machining instructions. During this module students will be taught to study and apply Engineering Design processes at conceptual and detailed levels for industrial products and components. They will be shown how to create and use engineering drawings using a propriety CAD package and how to analyse designs using FEA features in the package. Students will also be introduced to design philosophies that provide a basis on which to ensure a design is fit for purpose and as a result of completing this module successfully will be able to:

- Study an application of Engineering Design process at conceptual and detail levels

- Study of industrial products and components
- Creation and production of engineering designs
- Application of engineering theory to the design process
- Representation of Engineering Design concepts by sketching and CAD modelling
- Theory and application of CAD/CAM modelling
- Theory and application of FEA (finite element analysis)

5. TEACHING LEARNING AND ASSESSMENT STRATEGY

1. Academic Literacy
The treatment of academic literacy includes the knowledge and understanding of analytic subjects so that engineering analysis can be carried out using advanced software tools that integrate conceptual and analytic design. Having the knowledge and understanding of basic engineering scientific principles enables the student to correctly apply design specification (or operational) parameters to a design concept and carry out "what if" scenarios in order to determine suitability for purpose. The outcomes numbered one through five provide students with numerous examples of opportunities that exist in the workplace to teach, practice and assess the learning outcomes described and gain academic literacy relevant to their employment.

2. Research literacy
The Research literacy attribute, together with digital information literacy is developed through the process of preparing the group design report which outlines the design process they followed to produce a prototype solution. In addition there are individual tasks in the area of simulation analysis that requires students to carry out research literacy in order to enable them to solve problems in analytical manner as well so the computer simulations can be cross-checked.

3. Critical self-awareness and personal literacy
Is developed by students assessing their own work and the work of others through formative peer assessment of module coursework. And in the organisation of themselves and their groups in the completion of the assessment.

4. Digital Information Literacy.
Is developed through the requirement to use specialist computer software and related systems as well as prepare a suitably formatted report all of which demonstrate knowledge and aptitude for digital information literacy.

5. Active citizenship
Is developed through learning outcomes six and seven where students gain an understanding of their role as part of the group design work and how to present the work to a wider audience (i.e to their designated class set)

The learning outcomes are met by teaching in the form of lectures supported by seminars and group meetings. Students have a prescribed program of study guiding them through the development of the two group coursework submissions, an individual in-class test and a group presentation.

In addition to meeting the requirements of Graduate Attributes, the module must contribute to the learning outcomes matrix defined in UKSPEC by the IMechE and IEE. A table showing this contribution is provided above.

6. LEARNING HOURS *(10 notional learning hours per credit)*

Scheduled learning and teaching activities *(contact hours)*	
Lectures (including exercise practice)	14 hours
Seminars	14 hours

Practical classes/workshops	0 hours
Guided independent study	
Directed/independent study	92 hours
Preparation for assessments	30 hours
Placement/Study Abroad	
	0 hours
TOTAL:	**150 hours**

7. ASSESSMENT TASKS

7.1 Summative assignments (indicative)

Describe assessment tasks below…	Word count/ length of exam	Learning outcomes assessed	Weighting	KIS category
Coursework				
Assignment 1 (FEA)	2000	1,2,3,5	33%	1
Assignment 2 (CFD)	2000	1,2,4	33%	1
Assignment 3 (Group Design presentation)	30 minutes + questioning	1,2,3,4,5,6,7	34%	1 and 3
Written examinations				
N/A				
Other				
N/A				

7.2 Opportunities for formative assessment and feedback

Students will be set regular formative assessments in the form of quizzes presented through the VLE or simple design exercises with sample solutions that are peer assessed using the sample exercises as a marking guide.

Overall progress is monitored through formative feedback and regular meetings with the module leader and course tutor. An open door staffroom policy also gives students the opportunity to discuss coursework and assessment with the module leader.

8. INDICATIVE READING LIST

- Budynas, R. G. and Nisbett, K. (2014) *Shigley's Mechanical Engineering Design*, London: McGraw-Hill.
- Corbett, J., Dooner, M., Meleka, J. and Pym, C. (1991) *Design for Manufacture*, London: Addison-Wesley.
- Cross, N. (2008) *Engineering Design Methods: Strategies for Product Design*, London: Wiley.
- Kurowski, P. (2014) *Engineering Analysis with SolidWorks Simulation 2014*, Kansas: SDC.
- Pahl, G., Beitz, W., Feldhusen, J. and Grote, K. H. (2006) *Engineering Design: A Systematic Approach*, London: Springer.
- Simmons, Colin H. Phelps Neil, Maguire Dennis E. (2012) *Manual of Engineering Drawing: Technical Product Specification and Documentation to British and International Standards* 4th Ed., Elsevier.
- Tooley, M. and Dingle, L. (2004) *Higher National Engineering*, London: Newnes.

Date module first approved:	2010
Date of most recent revision:	April 2015

MODULE TITLE:	**Vehicle Electronics and Microprocessors**
MODULE NUMBER:	**ENGA5011**

1. MANAGEMENT DETAILS	
Module leader:	Marcus James
Level:	5
No. of credits:	15
Mode of delivery:	Face to Face
Pre-requisites:	N/A
Co-requisites:	N/A
Barred combinations:	None
Other restrictions or requirements:	None
Timetable information:	Semester 2, 14 weeks

Programme/s in which this module may be taken	**Status on programme**
FdEng Motorsport Engineering- BW13	Compulsory

2. MODULE AIMS

This module provides students with background knowledge and understanding of vehicle electrical and electronic systems and components. It also provides an opportunity for students to develop their ability to fault diagnose these systems. Analysis of vehicle microprocessor architecture and operation, hardware, interfacing and systems diagnosis is carried out and practical assignment tasks completed to ensure that students are familiar with programming languages and modern communications systems.

3. LEARNING OUTCOMES

On successful completion of this module, students will be able to:	** Brookes Attribute developed*	*Other GAs developed, if applicable*
1. Analyse, test and calculate voltage, current, resistance and power in a range of vehicle automotive circuits;	Academic Literacy	
2. Investigate the properties and characteristics of common semiconductor components;	Academic Literacy	Research Literacy
3. Interpret and show a full understanding of circuit symbols and diagrams;	Academic Literacy	
4. Analyse and evaluate the fundamental electrical characteristic operating principles of analogue and digital vehicle sensors and actuators;	Critical Self-Awareness and Personal Literacy	Research Literacy
5. Develop, produce, analyse and evaluate an electronic system and explain operation;	Academic Literacy	
6. Investigate, understand and use microprocessor architecture and operation;	Academic Literacy	
7. Investigate microprocessor interfacing;	Academic Literacy	

8. Analyse effective modern communication between vehicle microprocessors	Academic Literacy	Digital and Information Literacy
9. Analyse and develop electrical and microprocessor systems	Digital and Information Literacy	Active Citizenship
10. Measure system outputs and inputs to determine affective operation and use	Active Citizenship	Digital and Information Literacy, Critical Self-Awareness and Personal Literacy

*More details about the Brookes graduate attributes are available online at http://www.brookes.ac.uk/services/ocsld/sese/graduate_attributes.pdf.

UK-SPEC Learning Outcomes completed in this module:

The learning outcomes definition can be found, for example in the IET handbook of Learning outcomes: http://www.theiet.org/academics/accreditation/policy-guidance/handbook_lo.cfm

US1i	US2i					
✓						
E1i	E2i	E3i	E4i			
	✓		✓			
Di1	D2i	D3i	D4i	D5i		
			✓			
S1i	S2i	S3i	S4i	S5i		
			✓			
P1i	P2i	P3i	P4i	P5i	P6i	P7i
✓	✓			✓	✓	

4. OUTLINE SYLLABUS

Electrical

- Electrical and electronic concepts, voltage, emf, current, power, resistance, series and parallel circuits;
- Electrical properties and characteristics of semiconductor material: P-N junction diode, zener diode, N-P-N, P-N-P junction transistors, thyristors and integrated circuits.
- Operation of basic semiconductor circuits e.g. electronic ignition control module;
- Circuit diagrams: components, circuit symbols and circuit diagram layouts;
- Circuit design and manufacturing of PCB
- Use of multimeters and oscilloscopes for circuit measuring;
- Sensors: principles of operation, electrical characteristics of a range of analogue and digital sensors used in vehicle systems and testing of sensors;

- Actuators: principals of operation and characteristics of relays, solenoids, electro-hydraulic/pneumatic valves, rotary actuators and stepper motors, relevant test procedures for actuators;
- Display technology: analogue gauges, light emitting diodes, liquid crystal, vacuum fluorescent display, cathode ray tubes and relevant test procedures;
- Electronic circuit protection devices, fuses, circuit breakers, isolation switches and electronic fire extinguisher firing

MICROPROCESSOR ARCHITECTURE AND OPERATION

- Microprocessor architecture: block diagrams of microprocessor architecture, memory, input/output ports, counter/timer devices, address, data and control busses, central processor -function of arithmetic and logic unit, accumulator, system speed
- Microprocessor operation: binary and hexadecimal representation of data, addresses and instructions, the fetch/execute cycle, read/write operations to memory and input/output ports, modification of data stored in memory

MICROPROCESSOR INTERFACING

- Digital interfacing: digital input/output, use of interface circuits to drive display devices (e.g. LEDS), actuators and relays, signal conditioning to remove noise on digital inputs (e.g. inputs from pulse generators/switches, etc.), use of programmable input/output ports and counter-time ICs
- Analogue interfacing: digital to analogue conversion, analogue to digital conversion principles of operation, speed, resolution, applications, multiplexing of analogue sensor inputs prior to A to D conversion, use of microcontrollers in intelligent sensors
- PDM operation, programming, benefits and control of vehicle actuators (e.g. injectors, cooling fan motor, coil pack, fuel system and starter systems

COMMUNICATION

- Serial transfer principles: serial data transfer systems, speed of transfer, signal protocols, bus configurations, priority assignments, message format, error detection
- Vehicle networks: cabling - copper and fibre optic, connectors, protection, cost, reliability, power control, data acquisition and central management units, serial network implementation examples
- CANBUS systems, benefits, components, data transfer and uses for OBD2 diagnostics

5. TEACHING LEARNING AND ASSESSMENT STRATEGY

Students will study and understand modern microprocessor operation and build and analyse complex circuits. This is assessed through an assignment.
All students receive feedback for each assignment. They have a PDP form in which they record all constructive feedback and can write a reflective comment on how they will work on and overcome the criticism in the next assessment. They must also self-manage all of their assignments and therefore time accordingly.
All principles and technology is current and relevant to a range of different disciplines. The principles and theories learnt will also be carried out collectively in the classroom using the electronic equipment where teamwork is required.
Students will be expected to access not only books and web articles, but also eBooks and journals too, as the modules have a high emphasis on research. Our VLE provides great access to a range of journal databases and technical papers.

The learning outcomes are met by teaching in the form of lectures and supported by group work, discussions and completing exercises. Students have a defined program of study they must undertake. Seminars involve discussion and group presentation of ideas on set reading. Interaction is an essential element.
Graduate attributes are developed through these means. Students learn about basic programming in class, discuss them in seminars and use a variety of work tasks to develop a portfolio of knowledge which is then put into practice in the preparation of Picaxe programming

report of their own. This approach develops all five of the graduate attribute in varying measure as discussed in section three above.

In the completion of the assessment tasks students will apply development techniques acting with weekly guidance and be expected to direct their own work. Knowledge gained from reading set within the module together with knowledge sought in response to the assessment needs will be applied.

6. LEARNING HOURS *(10 notional learning hours per credit)*	
Scheduled learning and teaching activities *(contact hours)*	
Lectures	32 hours
Practical classes/workshops	10 hours
Guided independent study	
Directed/independent study	108 hours
Placement/ Study Abroad	
	0 hours
TOTAL:	**150 hours**

7. ASSESSMENT TASKS

7.1 Summative assignments (indicative)

Describe assessment tasks below…	Word count/ length of exam	Learning outcomes assessed	Weighting	KIS category
Coursework				
Coursework 1: Electronics & Microprocessors Principles	3000	4,6,7,8	50%	1
Coursework 2: Electronics & Microprocessors Application	3000	1,2,3,5,6, 9,10	50%	1
Exam				
N/A				
Other				
N/A				

7.2 Opportunities for formative assessment and feedback

All assignments are returned with formative written and verbal feedback to individuals and the group. This will enable the student to improve their work. Overall progress is monitored through formative feedback and regular meetings with the module leader and course tutor. An open door staffroom policy also gives the students the opportunity to discuss coursework and assessment with the module leader.
A module handbook is provided that includes case study questions on each topic to assess learners knowledge and understanding prior to summative assessment. Presentations are also included to assess learners knowledge.
Practical seminars of microprocessor programming and coding are closely monitored by module leader in sessions.

8. INDICATIVE READING LIST

- Bird, J. (2013) *Electrical and Electronic Principles and Technology*. 5th Ed. Newnes
- Bosch (2011) *Automotive Handbook* 8th Bentley Publishers
- Bosch (2013) *Automotive Electronics*. Robert Bosch GmbH. Springer Vieweg
- Crisp, J. (2004) *Introduction to Microprocessors and Microcontrollers*. Newnes.
- Lawes, J. (2006) *Competition Car Electrics.* Haynes, Yeovil.

Date module first approved:	2010
Date of most recent revision:	April 2015

MODULE TITLE:	**Mathematics II**
MODULE NUMBER:	**ENGA5015**

1. MANAGEMENT DETAILS	
Module leader:	Garth Palin
Level:	5
No. of credits:	15
Mode of delivery:	face to face
Pre-requisites:	ENGA4009
Co-requisites:	N/A
Barred combinations:	N/A
Other restrictions or requirements:	N/A
Timetable information:	Semester 1, 14 weeks

Programme/s in which this module may be taken	**Status on programme**
FdEng Motorsport Engineering- BW13	Core Optional

2. MODULE AIMS
This module provides a mathematical background for the study of engineering. Students learn the mathematics needed to support the analytical modules in year two. This includes the study of integral calculus and the use of associated functions, probability and statistics, numerical methods, essential applications of differential equations and matrix algebra.

3. LEARNING OUTCOMES		
On successful completion of this module, students will be able to:	** Brookes Attribute developed*	*Other GAs developed, if applicable*
1. Demonstrate the ability to apply techniques of integral calculus to a range of engineering applications	Academic Literacy	
2. Demonstrate the ability to use matrix algebra to solve systems of equations	Academic Literacy	
3. Use numerical and algebraic techniques to solve engineering problems	Academic Literacy	
4. Demonstrate the ability to use probability and statistics in engineering problems	Academic Literacy	Active Citizenship

*More details about the Brookes graduate attributes are available online at http://www.brookes.ac.uk/services/ocsld/sese/graduate_attributes.pdf.

UK-SPEC Learning Outcomes completed in this module:
The learning outcomes definition can be found, for example in the IET handbook of Learning outcomes: http://www.theiet.org/academics/accreditation/policy-guidance/handbook_lo.cfm

US1i	US2i				
	✓				
E1i	E2i	E3i	E4i		
		✓			
Di1	D2i	D3i	D4i	D5i	
✓					
S1i	S2i	S3i	S4i	S5i	
P1i	P2i	P3i	P4i	P6i	P7i

4. OUTLINE SYLLABUS

Matrix Algebra: matrix arithmetic, singular and non-singular matrices, determinant of a matrix, Gaussian elimination, solution of a set of simultaneous equations, consistency of equations and matrix transformations

Probability and Statistics: measures of central tendency and dispersion (mean, mode & median, standard deviation) for discrete and grouped data, laws of probability, dependent & independent events and conditional probability. Treatment of the normal distribution is optional.

Integral Calculus: standard techniques of integration including parts, partial fractions and substitution; applications to calculation of area, volume and mean value.

Numerical Methods: approximation of integrals by Simpson's and trapezium rule, solution of equations by Newton-Raphson iteration & bisection.

Further Topics (Optional, no assessment required):

- **Differential equations**: first order differential equations; second order differential equations and their application to engineering problems.
- **Laplace transforms**: definition, linearity property of Laplace transform, inverse Laplace transformation and solution of differential equations by Laplace transformation method.

5. TEACHING LEARNING AND ASSESSMENT STRATEGY

Students completing this module will have been given the opportunity to develop their academic literacy through attendance of lectures designed to cover the basic facts and present worked examples progressing from straightforward to more challenging.

Their academic literacy will be developed further through the application of mathematical analysis utilising the skills developed for engineering examples. Students will develop their ability to analyse and solve problems involving systems and practice those skills when measuring and evaluating experimental test data.

Formative Assessment: All students will receive guidance in approaches to problem solving and formative assessment will be undertaken at regular intervals throughout the module, both with individual students and with the group as a whole.

Summative Assessment: Class Tests 30% Exam 70%. Assessment of the learning outcomes for this module will be completed through class tests and examination based on application of relevant engineering mathematical theory to solution of problems. A minimum score of 30% must be achieved in every component of summative assessment in order to meet the subject specific regulations for the Foundation Degree.

6. LEARNING HOURS *(10 notional learning hours per credit)*	
Scheduled learning and teaching activities *(contact hours)*	
Lectures (including exercise practice)	56 hours
Seminars	0 hours
Practical classes/workshops	0 hours
Tutorials	0 hours
Fieldwork/external visits	0 hours
Guided independent study	
Directed/independent study	64 hours
Preparation for assessments	30 hours
Placement/Study Abroad	
	0 hours
TOTAL:	**150 hours**

7. ASSESSMENT TASKS

7.1 Summative assignments (indicative)

Describe assessment tasks below…	Word count/ length of exam	Learning outcomes assessed	Weighting	KIS category
Coursework				
2 Class tests	1 hour each	1,2,3,4	30 %	1
Written examinations				
Exam	2 hours	1,2,3,4	70 %	2
Other				
N/A				

7.2 Opportunities for formative assessment and feedback

The class tests will consist of a series of exercises which will allow the student to develop their mathematical abilities. Learning checks will take place at regular intervals throughout the module with formative feedback given to each student. Tutorial reviews will track the progress of individual students and identify areas of strength as well as actions for further development to assist students in developing techniques for the analysis and solution of problems involving mechanical and electrical systems, whilst measuring and evaluating experimental test data will develop both academic literacy and digital and information literacy.

8. INDICATIVE READING LIST

- Bird, J.O. (2010) *Basic engineering mathematics*. 5th edn. Oxford; Burlington, MA: Newnes.
- Bird, J.O. (2010) *Engineering mathematics*. 6th edn. Oxford; Burlington, MA: Newnes.
- Bird, J.O. (2010) H*igher engineering mathematics*. 6th edn. Oxford: Newnes.
- Croft, T. and Davison, R. (2013) *Engineering Mathematics: a Foundation for Electronic, Electrical, Communications and Systems Engineers*. 4th ed. Pearson
- Croft, T. and Davison, R. (2006) *Foundation maths*. 4th edn. Harlow: Prentice Hall.
- James, G. (2010) *Modern engineering mathematics*. 4th edn. Harlow, England: Prentice Hall.
- Lee, S. (2008) *An introduction to mathematics for engineers : mechanics* [Book with CD]. London: Hodder Education.
- Stroud, K.A. and Booth, D.J. (2011) *Advanced engineering mathematics*. 5th edn. Basingstoke: Palgrave Macmillan.
- Stroud, K.A. and Booth, D.J. (2012) *Engineering mathematics*. 7th edn. Basingstoke; New York: Palgrave Macmillan.

Date module first approved:	2005
Date of most recent revision:	April 2015

MODULE TITLE:	**Motorsport Fluid Dynamics**
MODULE NUMBER:	**ENGA5016**

1. MANAGEMENT DETAILS	
Module leader:	Josh Smith
Level:	5
No. of credits:	15
Mode of delivery:	Face to Face
Pre-requisites:	ENGA4011, ENGA4009, ENGA4010
Co-requisites:	N/A
Barred combinations:	None
Other restrictions or requirements:	None
Timetable information:	Semester 2, 14 weeks

Programme/s in which this module may be taken	**Status on programme**
FdEng Motorsport Engineering- BW13	Core Optional

2. MODULE AIMS

In this module, learners will be taught to understand the fundamental importance of aerodynamics and other associated fluid dynamics when applied to the motorsport industry. With this element of race car engineering making such a difference between winning and losing, the students will learn to calculate and apply aerodynamic principles to maximise performance of the modern racing car along with being able to demonstrate knowledge and understanding of heat transfer and thermodynamics.

3. LEARNING OUTCOMES

On successful completion of this module, students will be able to:	** Brookes Attribute developed*	*Other GAs developed, if applicable*
1. Investigate and analyse fluid dynamic properties based on Motorsport Engineering principles	Research Literacy	Academic Literacy
2. Compare and evaluate aerodynamic properties of vehicles and relate to road holding characteristics	Research Literacy	Academic Literacy
3. Design, produce, test, analyse and evaluate aerodynamic properties using CFD and the wind tunnel.	Research Literacy	Active Citizenship and Critical Self-Awareness and Personal Literacy
4. Present project findings in the form of a report and a presentation	Active Citizenship	Digital and Information Literacy and Research Literacy
5. Design a component/system and record the stages of the design process with suitable analysis	Research Literacy	Active Citizenship

*More details about the Brookes graduate attributes are available online at http://www.brookes.ac.uk/services/ocsld/sese/graduate_attributes.pdf.

UK-SPEC Learning Outcomes completed in this module:
The learning outcomes definition can be found, for example in the IET handbook of Learning outcomes: http://www.theiet.org/academics/accreditation/policy-guidance/handbook_lo.cfm

US1i	US2i					
✓						
E1i	E2i	E3i	E4i			
✓	✓	✓	✓			
Di1	D2i	D3i	D4i	D5i		
✓		✓				
S1i	S2i	S3i	S4i	S5i		
P1i	P2i	P3i	P4i	P5i	P6i	P7i

4. OUTLINE SYLLABUS

Aerodynamics

- Aerodynamics - forces and moments:
- Air flow over the exterior of the vehicle body and through the vehicle interior,
- Nature of the resultant aerodynamic forces due to air flow.
- Normal pressure and sheer stress, Viscosity property of air.
- Computational Fluid Dynamics.
- Separation of air flow lines over the vehicle body.
- Flow properties: Pressure distribution and vortex systems.
- Aerodynamic lift on vehicles: Ground effects, Increase of Downforce through vehicle body styling and utilisation of add on components.
- Effects of aerodynamic forces on vehicle performance:
    - Speed,
    - Rate of fuel consumption,
    - Acceleration,
    - Handling,
    - Braking,
    - Longitudinal,
    - Lateral and yaw moments.
- Design of scaled models and aerodynamic testing,
- Ideal vehicle body shape, Reduction of air resistance, Wake regions,
- Principles of aerodynamic force analysis, and its effects on the vehicle.

Fluid Dynamics

- principles of the gas laws,
- temperature in relation to absolute zero, relationships between PV&T,

- convection, radiation and conduction through materials,
- fluid flow,
- otto, carnot and diesel cycles, polytropic and adiabatic systems. Enthalpy and entropy.
- How turbo's, superchargers and calorific values of fuel effect burn rates.
- air flow, pressure, gas laws, effects of temperature, pressure, properties of air (density, reactivity, behaviour)
- Bernoulli's equation, venturi effect, convergent and divergent duct/nozzle flows and applications

5. TEACHING LEARNING AND ASSESSMENT STRATEGY

Students will be taught relevant theory and then put this into practise through the considerable use of Computational Fluid Dynamics (CFD). Each student will manufacture physical models to carry out physical tests in the college 100mph wind tunnel to confirm the accuracy of the CFD development work, as would be expected in the industry.

Learners will also sit an exam that covers most topics listed in the outline syllabus.

Fluid dynamics will be linked to engine performance, cooling and lubrication and assessed through theoretical calculation and case studies.

6. LEARNING HOURS *(10 notional learning hours per credit)*

Scheduled learning and teaching activities *(contact hours)*	
Lectures	24 hours
Practical classes/workshops	4 hours
Guided independent study	
Directed/independent study	72 hours
Preparation for assessments	50 hours
Placement/ Study Abroad	
	0 hours
TOTAL:	**150 hours**

7. ASSESSMENT TASKS

7.1 Summative assignments (indicative)

Describe assessment tasks below…	Word count/ length of exam	Learning outcomes assessed	Weighting	KIS category
Coursework				
Assignment 1: Fluid Dynamics	3000 words	1,4	40%	1
Written examinations				
Aero/Fluid Dynamics exam	2 hours	1,2	30%	2
Other				
Aerodynamic Presentation from CFD and Wind Tunnel	15 minutes	1-5	30%	3

7.2 Opportunities for formative assessment and feedback
Case studies for wind tunnel and CFD work allow staff to review students' knowledge and understanding of both software and hardware along with the understanding of results. Within the Fluid Dynamics element, question sets will be provided to provide feedback from each main topic. Overall progress is monitored through formative feedback and regular meetings with the module leader and course tutor. An open door staffroom policy also gives students the opportunity to discuss coursework and assessment with the module leader.

8. INDICATIVE READING LIST

- Barnard, R. H. (2009) *Road vehicle aerodynamic design: an introduction.* 3rd ed. St Albans: MechAero
- Katz, J. (2006) *Race Car Aerodynamics: Designing for Speed*. Bentley.
- McBeath, S. (2015) *Competition Car Aerodynamics*. Veloce
- Eastop, T. D. and McConkey, A. (1993) *Applied thermodynamics for engineering technologists.* 5th ed. edn. Harlow: Longman.
- Joel, R. (1996) *Basic engineering thermodynamics.* 5th ed. edn. Harlow: Longman.
- Rogers, G. F. C. and Mayhew, Y. R. (1992) *Engineering thermodynamics: work and heat transfer.* 4th ed. edn. Harlow: Longman.
- Rogers, G. F. C. and Mayhew, Y. R. (1995) *Thermodynamic and transport properties of fluids: SI units.* 5th ed. edn. Oxford: Blackwell.

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Date of most recent revision:	April 2015