UNIVERSITY OF NOTTINGHAM

DEPARTMENT OF ARCHITECTURE AND BUILT ENVIRONMENT

You need to identify the name of the School/Department and University from which the report emanated

Research Project (ABEE3036)

- A Detailed Guide for Students

Title

The title of the report should provide an accurate description of the work carried out. As part of their literature search, researchers will often perform keyword searches on databases.
They will usually check the title first to see if your report is relevant to their work

Jack B. Smith

Your Name

13 May 2025

Date Submitted

University Declaration

A dissertation submitted in partial fulfilment of the regulations for the Degree of Bachelor of Engineering in Architectural Environment Engineering at the University of Nottingham, 2025.

The Abstract and Acknowledgement should appear on separate pages. **NB** They have been put on the same page in this document to save on paper.

ABSTRACT

This document provides guidance on the K24X BEng final year module entitled 'Research Project' (ABEE3036). It describes what need to be considered when you select potential projects and supervisors and how you are going to be allocated a project and a supervisor based on your preferred choices. Information on how to plan and carry out the research work is provided along with the key dates when submissions of reports are required. Guidance on how to structure the written submissions, together with their marking criteria, is also given.

The Abstract should provide a succinct description of the project outlining the research '**motivation**, **aim/objectives**, **methodology**, **key results**, and **main conclusions**'. It allows others to quickly screen your work and assess if it is relevant to their own.

ACKNOWLEDGEMENTS

I would like to thank Dr Robin Wilson for providing the old version of this document. I would also like to thank other academic staff of the Department of Architecture and Built Environment for providing the brief description of their research topics/projects and feedback on this document.

You should write a brief and factual acknowledgement of any assistance you received while working on your project. This may include your supervisor, other academic staff, research staff, technicians, secretarial staff etc. who have assisted you.

Page numbering in the Preface should be in Roman numerals

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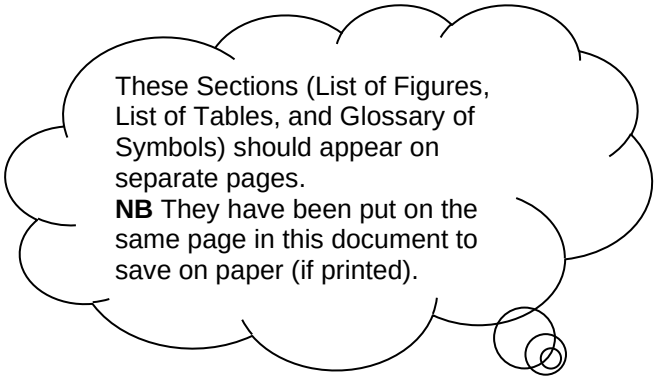

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Glossary of Symbols

E	Young's modulus	(N/m^2)
I	Electrical current	(Amperes)
V	Voltage	(Volts)
W	Power	(W)
c	Velocity of light	(m/s)
e	Energy	(J)
f_n	Natural frequency	(Hz)
k	Stiffness	(N/m)
m	Mass	(kg)
σ	Stress	(N/m^2)
γ	Strain	Dimensionless

CHAPTER 1 INTRODUCTION TO THE RESEARCH PROJECT

1.1 Introduction

As part of the final year of your degree course (K24X BEng), you are required to tackle the year-long module entitled Research Project (ABEE3036). If you pass the module (pass mark – 40), 15 credits are awarded for the Autumn Semester and 15 are awarded for the Spring Semester.

The Research Project aims to provide experience in the practice of engineering at a professional level. A useful way of viewing the Research Project is to imagine that it is the first task that you have been given by your new employer. You should aim to develop professional attitudes and working practices in terms of planning and executing your work, recording and reporting it, showing initiatives and taking responsibility. You will be expected to work hard, not only to obtain results, but also to think carefully about the interpretation, relevance and reliability of your results and about the process of carrying out the Research Project.

The Research Project provides an opportunity to:

- study a subject in greater depth than has been possible until thus far in your course,
- develop specific skills and knowledge related to the subject,
- develop a range of important, marketable, transferable skills.

At the end of the Research Project you should feel that you have not only increased your specialist technical knowledge and expertise, but also that you have improved your skills in work organisation, time management and report presentation.

1.2 The Role of the Supervisor

Chapter 2 deals with selecting a project and a project supervisor, but prior to doing so it is useful to know what the role of the supervisor is. The supervisor should facilitate and promote all the components of the work outlined in Section 1.1, not only by providing appropriate help and advice, but also by having high but realistic expectations of you.

You are entitled to expect regular progress meetings with your supervisor, the frequency of which will vary during the project according to the nature of the work and the needs of the student. One meeting per week, on average, should be regarded as the norm. At these meetings you should review progress, obtain appropriate help and advice and agree a course of action for the following phase of the work.

You should, however, bear in mind that the ultimate responsibility for a successful outcome to the project is yours.

1.3 Submissions

The following submissions are required to help assess your progress during the course of the project and then arrive at a final module mark for your work once the project is complete:

- **Interim Report** - You are required to submit (**via ABEE3036 Moodle**) a 1500 - 2000 words (main body of the report) Interim Report near the end of Autumn Semester

describing the project aim and objectives, methodology, the progress made in the Autumn Semester and the planned work for the remainder of the project.

- **Final Report** - You are required to submit (**via ABEE3036 Moodle**) a 7500 - 9000 words (main body of the report) Final Report towards the end of Spring Semester describing the project in detail.

- **Supervision Meeting Record Form** – All Project Supervision Meetings should be electronically recorded by the student using the Supervision Meeting Record Form shown in Appendix 1. You are required to submit the Supervision Meeting Record Form (**via ABEE3036 Moodle**) at the end of Autumn Semester and at the end of Spring Semester, respectively. The meeting record serves as a proof of engagement with supervision and an indication of progression on the Research Project. Further details on the Supervision Meeting Record Form are presented in Chapter 3.

- **Draft Final Report:** You are also required to submit an electronic copy of your draft Final Report to your supervisor by email before the deadline specified in Section 1.4. On-time submission of the draft Final Report will provide your supervisor an opportunity to give you feedback on the overall structure, logical order and technical quality of the report in advance of the final submission in May 2025. Failure to submit the draft Final Report on time without a good reason will be reflected on the mark awarded for Continuous Assessment by the supervisor and module convenor.

The deadlines of submissions are specified in Section 1.4, while detailed general guidance on the preparation, structure and content of the Interim Report and Final Report is given in Chapter 4. Your supervisor will be best placed to discuss these with you and to answer any questions specific to your reports. The word limits specified above apply to the main body of the reports. They have been devised deliberately to force you to think very carefully about how to condense and present large quantities of information in a limited amount of space. **A penalty shall be applied if a report is over the specified word limit when it is assessed – the Module Convenor will ensure this is strictly followed during the marking/moderation process.** The Marking Rubrics for the Interim Report and Final Report provide further information on the penalty. **The word count information on the main parts of your report must be provided on the last page** before the list of References.

You should bear in mind that the preparation of a good report takes time. A high quality report will require many rounds of editing and improvement. Marks are frequently lost because reports have been written hastily just prior to the submission deadline. If time permits, it is often useful to put the nearly completed report to one side and return to it after a few days. It is surprising the number of mistakes you will find if you read your draft report with a fresh pair of eyes.

Both Interim Report and Final Report will be subjected to plagiarism detection checks (further information on plagiarism in Section 1.7). **Late submission of either report without acceptable extenuating circumstances' evidence will be penalised by deduction of marks as described in the Quality Manual.**

1.4 Submission Deadlines

You are required to make the following submissions before the specified deadlines:

- **Interim Report**: Uploaded to **ABEE3036 Moodle** (as a single pdf file) before the deadline of **3:00pm (UK time), Thursday, 19th December 2024.**
- **Supervision Meeting Record Form** (as a single pdf file, for the Autumn Semester) – Uploaded to **ABEE3036 Moodle** before the deadline of **5:00pm** (UK time), **Thursday, 19th December 2024.**
- **Draft Final Report:** Email your Draft Final Report to your supervisor (cc Module Convenor liu.hao@nottingham.ac.uk) before the deadline of **3:00pm (UK time), Thursday, 27th March 2025.**
- **Final Report: Upload your Final Report** (as a single pdf file) **to ABEE3036 Moodle** before the deadline of **3:00pm** (UK time), **Tuesday, 13th May 2025.**
- **Supervision Meeting Record Form** (as a single pdf file, for the whole project period) – Uploaded to **ABEE3036 Moodle** before the deadline of **5:00pm** (UK time), **Tuesday, 13th May 2025.**

It is your responsibility to ensure the submissions contain all of the necessary information/pages.

1.5 Project Assessment

Many factors contribute to good project work. The quality and quantity of the work, the presentation of the reports and the manner in which you have gone about the project are all taken into account. Your **Interim Report** will be read and marked by your main supervisor. The Module Convenor and/or another academic staff will moderate the marking process of interim reports to ensure the same standards have been applied to the marking of all interim reports. Your **Final Report** will be read and independently marked by two members of academic staff. In some cases (e.g. **if the difference between the two awarded marks is greater than 10%**) additional members of staff or the External Examiner will also be asked to read and mark the work. Your performance during the research project period will also be assessed by your supervisor (in consultation with Module Convenor) through '**Continuous Assessment**' that considers your performance on project planning, communication, attitude, initiative and judgement, and draft Final Report submission.

Table 1.1 Breakdown of marks for the Research Project

Table title should be placed above the table.

Item of work	**Value**	**Person awarding mark**
Interim Report *(Split 75% for the research work undertaken and 25% for the quality of presentation of the report)*	20%	Supervisor only (*moderated by Module Convenor or another academic staff*)
Final Report (Split 75% for the research work undertaken and 25% for the quality of presentation of the report)	70%	Two members of staff (third marker may be needed)
Continuous Assessment (planning; communication; attitude, initiative and judgement; draft Final Report submission)	10%	Supervisor (*in consultation with Module Convenor where necessary*)

An outline marking scheme for the **Research Project** showing who will award the marks is given in Table 1.1.

Detailed marking rubrics (**available from ABEE3036 Moodle**) will be used for each aspect of assessment shown in Table 1. The 'marking rubrics' for the 'Interim Report' and 'Final Report' describe in detail what are to be assessed for the 'Research Work' and 'Presentation'. The marking rubrics for the 'Continuous Assessment' specify the weighting of each category of assessment (planning; communication; attitude, initiative and judgement; draft Final Report submission) towards the overall mark of the 'Continuous Assessment'. One intention of using detailed marking rubrics is to make the marking process fair and consistent. The other intention is to provide students a point-by-point check list on marking criteria during the preparation stage of the Interim Report and the Final Report. Therefore, **this Research Project Guide should always be read in parallel with the marking rubrics.**

1.6 Confidentiality and IP Issues

Some research projects may be connected with a confidential research programme - if this is the case, your supervisor will expect that you agree with the requirement of confidentiality at the beginning of your research project. The requirement of confidentiality will have little restriction on the writing of your research project reports but may have restrictions on the publications of the research project results. Some projects may generate commercially exploitable intellectual property (IP) – if this is the case, the University's policy on Intellectual Property Rights (IPR) [1] applies.

1.7 Research Ethics

Research has the potential to generate valuable new knowledge, however, it is important that in the process of undertaking our research work we consider the potential harm that might be associated with either the process or our findings. Research ethics provides a framework within which benefit and harm may be weighed up and measures identified, where relevant to minimise the latter. It also allows us to identify the line, beyond which, research should not be conducted.

BEng/MEng research projects are often technical in nature and represent little to no risk in relation to potential harm. Where research questions overlap with issues such as building user experience, or other areas that involve the use of human subjects, it is important that the research method is subject to third party scrutiny such as School, Department or Faculty Research Ethics Review Committee to test the balance of benefit to potential harm.

Irrespective of the extent to which your research project is likely to bring with its ethical considerations, it is important that you reflect upon its likely ethical impact as you develop your research method. **You are required to include with the Research Project Supervision Form a statement that confirms ethics have been considered and that approval is either required or unnecessary.** You will be provided with further guidance on how ethics affect the process of research, how you can decide whether ethical approval is required, and if it is, how you can get ethics approval.

Just as the Research Project module seeks to develop research skills and as part of this, folds in the process of ethics, you are reminded that as a professional engineer, you will be responsible for making decisions that can impact positively and negatively on the lives of others. The awareness and skills you are developing in relation to research ethics overlap strongly with those linked to design. You are encouraged to carry the lessons you learn here across into your professional life and use them as a gauge to inform your practice.

1.8 Risk Assessment

Understanding that what we do and what we ask others to do in the workplace carries risk, seeking to quantify what that risk might be, and identifying safe ways of working that help to mitigate risk is central to healthy and safe working within the built environment.

Within the University, there are formal procedures we must adhere to that set out a framework within which we can assess our research plan, explore options to reduce risk, and then ultimately decide whether a research task can either proceed as planned or whether we must find an alternative way of working. You will have encountered these in your studies to date (e.g., safe working in the model making workshop, arrangements for safe participation on field trips, etc).

The Research Project module provides an opportunity to assess potential risks and where necessary, to propose risk mitigation strategies, within the context of a research project that you will be working on for one academic year. You need to be an active participant in the process, rather than a passive recipient of safe ways of working. It may be that on reflecting on your research plan, risk is minimal, and a risk assessment is not needed. Simulation projects might be an example that falls into this category. It may be that you are working in a laboratory setting on an experimental rig for which safe ways of working currently exist and you can work within these. It may be that you are developing a new experimental system and you need to assess potential risks associated with each component and/or the whole system from the ground up.

For each Research Project, we require that you reflect on the level of risk associated with your proposed activity and ensure that the process is recorded. **You can do this by completing a statement contained within your supervision record.** Where a risk assessment is required, or where you work within an existing risk assessment, details should be provided as part of your research methodology.

Your degree is preparing you for work within an industry that historically has had a poor record in relation to harming those it employs. The process you practice in relation to your Research Project is representative of part of the health and safety working procedures you will work within, and for which, along with your fellow workers, will be responsible for. The skills you practice in this module form part of your diet of lifelong learning linked to your profession.

1.9 Plagiarism and Academic Misconduct

Research often builds on the work of others. On many occasions it may be useful to include material produced by others in your research project report, e.g., when describing the background to your project. Under such circumstances it is extremely important that you clearly distinguish work that is yours from that of others. Failure to do so may lay you open to charges of **plagiarism**, which is treated by the University of Nottingham as an act of **Academic Misconduct**, comparable to **cheating in exams**.

The University's Quality Manual [2] defines **plagiarism** as *"representing another person's work or ideas as one's own. For example by failing to correctly acknowledge others' ideas and work as sources of information in an assignment, and neglecting use of quotation marks.*

This also applies to the use of graphical material, calculations etc. in that plagiarism is not limited to text-based sources. "

Other examples of Academic Misconduct related to **Research Project** described by the Quality Manual [2] include:
*"**False Authorship**: where a student is not the author of the work they have submitted. This may include a student submitting the work of another student. This may also include the submission of work that has been produced (in whole or in part) by another student or third party. As it is the authorship of an assignment that is contested, there is no requirement to prove that the assignment has been purchased."*

***"Fabrication or misrepresentation**: the presentation of fabricated data, results, references, evidence or other material or misrepresentation of the same. Including, for example:*

- *claiming to have carried out experiments, observations, interviews or other forms of research which a student has not , in fact, carried out;*
- *falsely claiming to have obtained results or other evidence;*
- *in the case of professional qualifications, falsely claiming to have completed hours in practice or to have achieved required competencies when this is not the case;*
- *submitting a false Extenuating Circumstances claim where the claim and/or evidence has been fabricated/falsified."*

The possible penalties for Academic Misconduct and Plagiarism may include:

- **A mark of zero for the entire piece of coursework or assessment** in which the academic misconduct has occurred.
- **A mark of zero for the entire module** in which the academic misconduct has occurred.
- **Award a mark of zero for all the assessments in the semester** (even where this will lead to, for example, a reduction in degree class or the award of a lower qualification). In the case of year-long modules, this penalty may affect both semesters.
- **Award a mark of zero for the whole year** (even where this will lead to, for example, a reduction in degree class or the award of a lower qualification) etc.

The notes on referencing material, given in Chapter 4, provide useful guidance on how to avoid problems with referencing. **The University/Department/Module Convenor/supervisor reserves the right to check your electronic submissions with Plagiarism Detection Software**.

1.10 Policy on the use of Artificial Intelligence (AI)

Both the Interim Report and Final Report of K24X BEng Research Project module should be completed entirely without AI assistance, which is the default position of the University in section 2.1 of the policy on academic misconduct.

CHAPTER 2 SELECTING A PROJECT AND FINDING A SUPERVISOR

2.1 Introduction

This chapter contains suggested research topics/projects and the names of the academics who could act as the Supervisors. The same pool of the supervisors are going to supervise the Architectural Environment BEng and MEng Research Project students. On average, each supervisor is expected to supervise 3 to 4 BEng/MEng students for 2024/2025. In order to spread the workload evenly, it has been decided that **the maximum number of BEng/MEng students supervised by one academic staff is limited to 4 for 2024/2025**.

2.2 List of academic staff and potential research projects/topics

Projects fall into three main categories: laboratory-based; computer-based; and literature-based. Each category of projects has its own advantages and disadvantages. For example, laboratory-based projects can offer plenty of hands-on experience but may face unexpected difficulties (such as breakdowns of instruments) and restrictions (e.g., restriction on working hours for laboratory tests, capacity limit due to social distancing or no access to laboratory buildings during disease outbreaks). On the other hand, while computer-based projects allow you to work long hours in a day, you may encounter software problems such as software bugs that may take the software company well above one year to correct.

BEng/MEng Research Project Topics/Projects for 2024/2025 are listed below with each main supervisor. Some of the listed projects are described with great details, while others may only contain the project title or research topic. All academic supervisors have been told that students may make an enquiry or request a meeting (virtual or in-person) to discuss their listed topics/projects after the Research Project Introductory Lecture. After the Introductory Lecture, you will have 7 to 10 days to choose your preferred projects/topics (see Section 2.4). Before you finalise your choices, you should try to find more about the topics/projects through literature search and/or discussion with the potential supervisors.

Dr Rabah Boukhanouf: In addition to the listed projects, Rabah is also willing to accept suggested suitable topics in the field of heating/cooling in buildings.

(1) Impact of Heat Pump Uptake on Electrical Grid Dynamics: Insights from Literature.
(2) Electrification of Home Heating and Hot Water in the UK: a comparative analysis of system design alternatives.
(3) Investigation of solar assisted air conditioning system using computer modelling.

Dr John Calautit:

(1) **Machine learning based occupancy detection system and method for use in building controls** – Solving the challenge of predicting occupancy is crucial to design and operate efficient office spaces and automate systems in these facilities. This project will use artificial intelligence techniques such as machine learning to detect and predict occupancy in a building for the control of energy systems. The Faster Region-based Convolutional Neural Networks will be employed for the detection and EnergyPlus will be used for energy modelling.
(2) **Vision based detection system for healthy indoor spaces** - This project will use vision-based techniques to enhance the indoor environment quality in buildings. The

aim is to detect issues that would cause poor indoor air quality and alert occupants and building owners. Algorithms such as Faster Region-based Convolutional Neural Networks and YOLO will be employed.

(3) **Vision based thermal comfort detection system** - This project will use vision-based techniques to detect and predict the clothing and activity level of occupants to estimate the real-time thermal comfort for use in the control of HVAC. The aim is to balance good thermal comfort and energy efficiency. Algorithms such as YOLO and Faster Region-based Convolutional Neural Networks will be employed along with available clothing datasets.

(4) CFD and experimental testing of an innovative passive cooling and ventilation system for multi-storey buildings – This project will develop a new passive cooling and ventilation system which can be incorporated to multi-storey and multi-zone spaces. CFD modelling will be used to assess the feasibility of the system and experimental testing will be carried out to verify the numerical results.

Prof Jo Darkwa:

(1) Thermal enhancement of phase change materials for domestic and industrial energy storage applications.
(2) Variable energy storage technologies for district heating systems.
(3) Integrated energy storage technologies for the built environment.
(4) Energy efficient roofing systems for hot climates.
(5) Thermochemical energy storage systems for industrial waste heat application.

Dr Benjamin Jones: The focus of Ben's work is on measurement and modelling approaches to the indoor environment that can inform policies to create low-carbon and healthy building stocks. He is particularly interested in the energy efficient ventilation of buildings and its relationship with indoor air quality and occupant health.

(1) **The consequences of electrification in houses on health:** Houses around the world are having their gas heating and cooking systems replaced by electric equivalents. This could improve the health of occupants, but it may also have positive effects on ambient air quality. What are these effects?
(2) **Measuring fine particle emission rates from vacuum cleaners:** Vacuum cleaners suck up dust and dirt and store it in a bag or chamber. However, the smallest particles may escape filtration and be recirculated into indoor air. These particles are a health risk. Therefore, it is important to understand the rate at which particles are emitted, and to identify measures that may mitigate against exposure to them.
(3) **Understanding exposure to fine particle emission rates from cooking in houses:** Cooking is thought to be one of the primary sources of particulate matter indoors. The cook is likely to have the greatest exposure to them, but what is the exposure of other householders? What behaviours can be implemented to reduce exposure?
(4) Any other project that relates to IAQ, pathogen exposure, and ventilation.

Prof Hao Liu: Hao's research interests include low carbon energy and resources technologies, biomass/bioenergy, combined heat and power generation, waste management and disposal, energy from waste, combustion, carbon capture etc.

(1) **Sustainable waste management & disposal: this is a desktop-based project and may be taken by more than one student (up to three) focusing on one of the**

following aspects: waste-to-energy technologies, a comparison of waste management and disposal practices between different regions/countries or the feasibility study of plasma gasification for the United Kingdom/another country. The student who wishes to do research on plasma gasification should be willing to learn new knowledge on plasma gasification. It is worth noting that all BEng Year 3 students will learn 'Waste management and disposal' in Spring Semester as a part of the module 'Energy and Waste' taught by Prof Hao Liu.

(2) **Biomass heating/CHP for domestic and commercial buildings' application:** this is a desktop-based project, but it involves the use of the free-to-use software 'RETScreen'. After reviewing the biomass heating/CHP technologies, the focus of the project will be to analyse the economic and environmental benefits of biomass heating/CHP applied to domestic and commercial buildings using Case Studies to be collected from open literature. It is worth noting that all BEng Year 3 students will learn 'Biomass Fuels' in Spring Semester as a part of the module 'Energy and Waste' taught by Prof Hao Liu.

(3) **Life cycle analysis (LCA) on the productions of biofuels, aviation fuels or hydrogen:** this is a desktop-based study but may involve the use of the free-to-use software 'GREET life-cycle model'. The productions of a range of biofuels (bioethanol, biodiesel, biogas, solid biomass fuels), aviation fuels and hydrogen can be investigated with focuses on the review of the production technologies and life cycle analysis on energy uses and emissions. **The project can be taken by more than one student (up to three), but they will focus on different kinds of fuels: biofuels, aviation fuels or hydrogen.**

Dr Sara Mohamed:

(1) **Overheating in Passive House Buildings under Future Climate Conditions Using Computer Modelling Software**: This project will use advanced simulation software to model the effects of future climate scenarios on passive house buildings. Students will evaluate overheating risks and propose mitigation strategies using tools such as IES VE.

(2) **Reducing Embodied and Operational Carbon in UK Housing and Offices**: This project explores strategies to reduce both embodied and operational carbon in UK housing and office buildings. Students will analyse low-carbon materials, energy-efficient systems, and retrofitting options, providing recommendations to help minimize carbon emissions throughout the building lifecycle

(3) **Cross-Stack Height Effect of Windows on Ventilation in UK Classroom Design Using CFD Simulation:** This project examines the effects of cross-ventilation and window placement in UK classrooms using Computational Fluid Dynamics (CFD) simulations. Students will explore how both single and cross-ventilation systems impact airflow efficiency and thermal comfort and will provide recommendations for optimal design configurations.

(4) **Indoor Air Quality (IAQ) in General Practitioner (GP) Practice Rooms: Measuring IAQ in Nurse and Consultation Rooms:** This project involves assessing indoor air quality in GP practice rooms, especially where the use of natural ventilation is limited due to concerns over noise, privacy, or contamination. Measurement tools for IAQ will be used to analyse real-time data and provide recommendations for improving air quality.

Dr Siddig Omer:

(1) **Impact of energy storage for large-scale renewable energy-grid integration** (a case for Electric vehicles acting as energy storage or energy carrier).
(2) **Holistic Residential Retrofitting Passive Design Potential in Hot Climates:** This study aims to test the contribution of holistic retrofitting packages to further understand the dynamic nature of their interaction, and their sensitivity to different future financial scenarios to determine the cost-prime optimized solutions.
(3) **A techno-economic analysis of green hydrogen energy from North Africa based on renewable import to central Europe:** The project aims to put forward a scenario for a proposed green hydrogen production and supply to Europe, considering renewable conversion to help meet decarbonization targets for Europe.
(4) **Develop a Model for Calculating Operational Carbon that utilizes Future Weather data**. The project may include:
    - Surveying International Zero-Carbon Goals and Bodies Responsible.
    - Review of Standards, Codes, and Regulations related to Zero-Carbon Building Design.
    - Review of Calculation Methods for Operational and Embodied Carbon.
    - Investigating Future Weather data usage for Operational Carbon Calculation.
    - Developing Operational Carbon Calculation Models that consider expected weather patterns and other relevant factors to achieve zero-carbon building strategies.

Dr James Pinchin: James' research interests include 'methods for person tracking & occupancy detection', 'activity detection', 'movement modelling of individuals' and 'smart building technologies':

(1) **Air quality in a General Practitioners office:** Can we reduce the risk of disease spread for patients visiting their doctor by managing the flow of people through the office space?
(2) Critical literature review on **sparse crowd movement simulation**.
(3) **Tiny battery, large house:** Can we make better use of small capacity energy storage in residential buildings if we can understand and predict the occupant's likely energy use?
(4) **Analysis of WiFi derived occupant counts in urban open spaces**: This project will assist with the analysis of long-term person count datasets in Nottingham's parks & open spaces. Familiarity with Matlab would be useful, but project could be done with Excel.

Dr Rob Shipman: Rob's work involves the use of data science and machine learning to optimise the performance and sustainability of systems and networks at the building, community, or city level. His current focus is on smart local energy communities integrating EVs into the energy system through use of vehicle-to-everything (V2X), and digital twins. Potential projects are listed below but he will also consider other projects that fit into the areas highlighted above.

(1) **The impact of EVs on a local energy community**: This project will use real data from a community energy scheme to help assess the impact of large-scale EV adoption. It will identify approaches to help manage EV charging for the benefit of the community.

(2) **AI - predicting building energy demand using machine learning**: This project will explore the use of generative AI to create machine learning models that predict future energy demand from a building or buildings. The system will be trained and assessed using monitoring data from real buildings. Some prior experience of computer programming (Python in particular) would be desirable.

(3) **Digital twins:** this project will conduct a critical review of the use of digital twins within the built environment. It will identify the current state-of-the-art, limitations and opportunities. An informational digital twin of a campus building will be developed using industry-standard toolsets (Autodesk Revit and Tandem).

(4) **Self-organising energy systems:** this project will investigate the use of "bottom-up" systems to optimise the utilisation of local renewable energy, EV charging, and satisfaction of building electricity demand. An agent-based model of a local energy system will be created to simulate such a system.

Prof Yuehong Su:

(1) Parametric study of daylighting performance for a building with installation of automated shading devices (using Revit or IES software).

(2) Simulation and parametric study of passive ventilation/heating/cooling integrated with phase change materials (using EnergyPlus or DesignBuilder).

(3) Simulation study of a dual air and ground source heat pump (using EnergyPlus or DesignBuilder).

(4) Simulation and analysis of a Photovoltaics/Thermal system incorporated with a Radiative cooling for applications in buildings (partly using Revit or IES or EnergyPlus).

(5) Optimisation and off-design analysis of the Rankine cycle for heat recovery applications (using Matlab or EES).

Dr Robin Wilson:

(1) **Cellulose city** – If we transition from silica to cellulose in the creation of buildings, can we convert our cities from carbon source to carbon sink?

(2) **Nuts and bolts** – We all know that mechanical systems in buildings drive operational energy and contribute to carbon emissions. This project requires you to take a step back and consider the embodied emissions that occur before your lovingly specified machines arrive on site.

(3) **IES vs Excel** – Building simulation tools such as IES offer a valuable insight into the energy behaviour of buildings and the levels of comfort they offer their users. Can you do just as well with a spreadsheet?

(4) **Blurry boundaries?** – Lacaton and Vassal's renovation of 3 social housing blocks in Bordeaux offered an alternative to cladding buildings with insulation for improving thermal performance – instead they created a free running semi-inside/outside space that offered residents more room to live in addition to improved thermal comfort. Your challenge – apply your skills in energy simulation to answer the question: 'does the strategy work?'

Dr Christopher Wood:

(1) **Experimental Investigation utilising the Pulse air-tightness technique** to determine effective leakage areas of intended openings in the building fabric. The Pulse

technique of measuring a building's airtightness was developed within the department of Architecture and Built Environment at the University of Nottingham. This investigation will use the Pulse method to determine the effective leakage area of different openings within the fabric of a building. Effective leakage area of openings such as vents is important in providing calculations of background ventilation rates within buildings.

(2) **Design of a solar thermal, multi-level energy storage system for a small Northern European district heating scheme.** This is a theoretical investigation into the possibility of storing enough solar heat throughout the year to enable a small residential district to be heated throughout the winter season. The investigation will look at thermal generation and demand profiles and assess how the mismatch between the two can be overcome to provide the dwellings with enough heat through the winter months.

(3) **Experimental investigation of fabric thermal performance using heat flux and co-heating measurement techniques.** This is an experimental investigation where the thermal performance of two experimental buildings is investigated. Experimental means include co-heating tests, which measure the whole building heat loss coefficient and also elemental investigations by using heat flux sensors on walls etc.

(4) **Design of an under-pitch heating system for use with sports pitches i.e. football, rugby pitches etc.:** This is a theoretical investigation into the design and operation of a under-pitch heating system. This could include aspects such as under-pitch heating circuit, energy supply (renewable or not?), detailed investigation of the heat transfer in the soil around the delivery, etc.

Prof Yupeng (Jack) Wu: Jack's research interests include solar façade, smart window, renewable/sustainable energy technologies and their application in built environment. Potential research projects are listed below.

(1) **Solar forecasting using ground-based weather array for grid balance**: This project aims to understand the electrical grid's requirements and assess the impact of PV (photovoltaic) output on grid stability. It will involve the development of an AI model for short-term PV prediction to facilitate grid balance.

(2) **Enhance the Accuracy of PV Prediction Models:** This project aims to evaluate the accuracy of prevailing solar prediction models, such as Sandia, PVsyst, and PVWatts, across various solar technologies, including c-Si, a-Si, and CdTe. The next step is to identify areas for improvement and implement enhancements to optimise the models' accuracy.

(3) **Evaluation of Visual Effects on Occupant Health and Well-Being in an Office Environment:** This project aims to assess the impact of visual factors, such as lighting and glare, on the health and well-being of occupants in an office environment. This will be achieved through carrying out experimental tests in a VR environment to evaluate how window colour and office interior design influence comfort, productivity, and overall well-being, leading to recommendations for improved office design.

(4) **Optimise the Energy Generation, Storage, Consumption, and Trading with the Grid: A Case Study of a Farmhouse in Nottingham:** The project involves a comprehensive evaluation of a farmhouse's energy management by first reviewing its consumption patterns, including peak usage times, seasonal variations, and overall demand. It will then examine the efficiency and performance of the 30 kWp PV system, considering factors like solar irradiance, system wear, and energy output.

Strategies will be developed to optimise the 30 kWp energy storage system, focusing on efficient charging, discharging, and integration with the PV system. Additionally, opportunities for grid energy trading, such as selling excess energy or participating in demand response programs, will be explored. Finally, a cost-benefit analysis will assess the financial advantages of these optimisation strategies, including potential savings and return on investment.

Prof Yuying Yan:

(1) **Turbulent flow heat transfer and heat transfer enhancement**: Using available software of CFD to simulate forced internal turbulent flow heat transfer or heat transfer enhancement. The numerical results should be verified by available testing results.
(2) **Nature inspired technology for built environment and energy storage**. The research will focus modelling or testing on interfacial behaviours (such as drop spray, evaporation, condensation) of liquid-gas/vapour on solid surfaces morphologies mimicking from nature.
(3) **Energy generation or harvesting**. Thermoelectric generation and heat pipes technologies will be applied to recover energy from waste heat sources such as car or boiler exhaust gases, and other types, etc. Thermodynamic analysis, numerical modelling, or testing; or combinations of modelling and testing will be applied.
(4) **Thermal management for energy systems** such as power electronics, electric cars, etc. Phase change heat transfer or heat transfer enhancement technologies will be considered and applied. The project will be in numerical modelling or experimental testing, or combination of numerical and testing.

Dr Xiaofeng Zheng:

(1) **Experimental investigation of the indoor air quality of a UK home:** Much of the human exposure to air pollutants occurs indoors. The indoor pollutants can be contributed by outdoor concentration, but also by indoor sources and building ventilation, and therefore reduction of outdoor air pollution alone is not necessarily sufficient to safeguard the public from the effects of air pollution. Indoor air is polluted by a wide range of sources, from excess CO_2 to food particles, vapour from cooking, dust, moisture from baths, showers and washing machines, VOC released from human-made products such as wall paints, scents; and naturally occurring chemical compounds such as indoor plants and pet hairs. Studies have also found that the indoor air is 5 times more polluted than outdoor air and especially children's rooms are often the most polluted in a home due to insufficient ventilation. Poor indoor environment in short term can cause sick building syndrome such as irritations, headache, fatigue, etc. and in long term can lead to serious health problems, such as increased risk of asthma. Therefore, an effective and practical ventilation strategy is highly important and necessary for creating a healthy indoor environment. Most of UK homes are naturally ventilated and issues with indoor air quality are increasingly reported. This research aims to investigate the quality of indoor air in a typical UK home during heating season.
(2) Desktop-based feasibility study of year-round food production in passive solar green house in the UK: As we strive to make our buildings more energy efficient and adaptive to the changing climate, we also need to think about the future food supply and security in front of the constantly changing environment, not to mention the growing population. Currently, UK largely relies on importing food from other

countries, leading to increased food mileage, compromised freshness and insecure affordability. Therefore, it is important to carry out research to explore the feasibility of developing low carbon passive solar greenhouse in the UK to improve its agricultural capacity and sustainability. We can apply the same principles that we have learned about the buildings to provide a controllable and environmentally resilient growing conditions for our future food production. This research aims to understand the feasibility of doing so in the UK, given its unique climate and propose a suitable greenhouse solution that suits UK and countries with similar climate.

(3) **Investigation of utilising low carbon materials to construct buildings with reduced embodied carbon in the UK**: In the last decades, we have been focusing on how to minimise the operational carbon and we've made tremendous progress. As buildings become more and more energy efficient in future, it is the embodied carbon that will be the major contributor to the overall building carbon emission. Therefore, it is important to minimise the building carbon emission through the increased use of low carbon materials and adaptive design. This research aims to investigate how such target can be achieved in the UK context.

(4) Development of a testing procedure and methodology for mapping leakage distribution of a UK home: Domestic buildings are traditionally treated as a single zone space to understand their building physics such as an envelope's airtightness and u-values. Current energy and ventilation models are mostly based on that assumption, which represents a good starting point of understanding how a typical home behaves as a single zone. However, not all spaces in a home are occupied simultaneously. Therefore, the actual demand for room conditioning and ventilation is lower than what is usually provided in current practice. In the context of climate emergency, there is an increasing need of minimising the energy consumption of homes. The recent energy crisis makes it increasingly unaffordable to condition a whole home, resulting in the part heating of homes to a reduced temperature and/or for a reduced duration. Zonal heating of a home presents an opportunity of saving energy but requires a correct zonal isolation to be effective. This also poses a challenge to home ventilation considering UK homes mostly rely on background ventilation to dilute indoor pollutants. Given the ventilation openings are disproportionately distributed in the building envelope, zonal operation without constructive knowledge of how building might behave would lead to a compromised thermal comfort and exacerbated indoor air quality issues. Therefore, it is important to obtain a deeper understanding of the building physics both at whole and zonal level, which would allow us to minimise the energy consumption for conditioning and ventilation without compromising indoor air quality. This research aims to develop a testing procedure and methodology for the measurement of zonal airtightness and mapping of leakage distribution using the UoN invented Pulse technology.

Dr Jie Zhu:

(1) **Heat transfer correlations for supercritical pressure fluids in the horizontal flow mode**: This project aims to summarize existing heat transmission equations through the literature study and analyze existing heat transfer equations for supercritical pressure water and carbon dioxide in the horizontal ducts. The project objectives include 1) analyses of the existing heat transfer correlations in horizontal flow mode. 2) comparison of the calculation results with the available literature data. 3) develop new correlations for the horizontal flow mode.

(2) **Performance investigation of nano-fluid based photovoltaic thermal system (PV/T)**: This project will be conducted by developing simulation model to assess the PV/T system energy performance, which is cooled by nano-fluid. The project involves literature study, mathematic modelling and computer simulation to achieve the research objectives.

(3) **Performance study of an integrated PVT and heat pump system**: A novel energy system is proposed by integrating photovoltaic thermal technology with heat pump. The heat sources of the system come from various aspects, their energy performance under different operating conditions will be assessed, and the theoretical study will be carried out. The project aims to achieve the highest annual energy performance under the local weather condition, the optimum operation state will be developed by developing mathematic model and simulation program.

(4) **Configuration investigating of energy pile and ground source heat pump:** The building foundation can be used in the energy system with energy pile function, different ground heat exchanger designs will be evaluated, correspondingly the system annual energy performance under different system designs will be assessed, the project aim is to optimize the system integration configuration to achieve high energy performance.

(5) **Working fluid selection study in energy pile unit:** The project aims to select the most suitable working fluids in energy pile unit which is linked to a ground source heat pump. Various working fluids will be assessed by theoretic study with considerations of heat transfer and fluid flow states in the unit, the pipe unit energy performance comparison will be conducted based on the simulation results.

2.3 Alternative Research Projects

You are not restricted to the research projects/topics given in this chapter. If you have an idea of your own that you feel would make an interesting project, discuss it with the Module Convenor or other academic staff. They should be able to give you an indication of whether the work is feasible and suggest a suitable supervisor.

The main supervisor has to be one of the academics within the Department of Architecture and Built Environment. This is to ensure that the deadlines of marking can be met and consistent marking criteria are followed by all markers. Other qualified researchers and academics can act as the co-supervisor of a BEng/MEng research project subject to the agreement of the Module Convenor and/or the main supervisor.

2.4 Choosing preferred projects/topics and supervisors

In order to evenly distribute the workload of supervision among all academic staff and give the Module Convenor every chance to allocate a project that is of interest to you, you are asked to choose up to 4 preferred research projects/topics listed in 2.2. In addition, you can also suggest your own research project. The form of choices for your preferred projects and supervisors is given in Appendix 2. **You need to fill the form (**in Excel format**) and submit it via the ABEE3036 Moodle before the deadline to choose your preferred projects/topics (3:00pm, Friday, 11 Oct 2024).**

After receiving all of the choice forms, the Module Convenor will allocate a project and a supervisor to each BEng/MEng student according to the following criteria:

(1) The general principle is to consider a student's choices in the order of the first, second, third and fourth choice;

(2) If there is only one student who chooses a project as the first choice or second choice, the student will be allocated this project and the supervisor, providing that the supervisor has not exceeded his/her limits in the numbers of BEng/MEng project students;

(3) If there are two or more students who choose a project as the first choice or second choice, the third or fourth choice will be considered in conjunction with the number of project students already allocated to the related supervisors;

(4) If you have suggested your own research project and a supervisor, your own topic/project will be considered as an equal first choice, providing it is considered as a suitable BEng research project;

(5) If the above procedures fail to allocate a student a project/supervisor that is one of the student's preferred choices, the Module Convenor will allocate a project/supervisor to the student after considering the student's general interests (reflected by his/her choices) and the profiles of staff workload. The student will be given a chance to discuss the allocation with the Module Convenor and/or the allocated supervisor. **It is worth to remember on occasions the allocated supervisor may be able to offer a non-listed project to match the student's preferred research interest.**

CHAPTER 3 PLANNING YOUR WORK

3.1 Introduction

Once you have been allocated a project/supervisor, it will be necessary for you to draw up an Overall Work Plan. This will be used to identify those parts of your project that will be assessed for the Autumn Semester. You are required to submit a short report (the **Interim Report**) documenting the work completed during Autumn Semester and **a detailed work plan** for **the remainder of the project**. Progress made during the Autumn Semester will be judged against the Overall Work Plan. Towards the end of Spring Semester, the Final Report describing the project in its entirety will need to be submitted. Further details on the format and requirement of the Interim Report and Final Report will be described in Chapter 4.

3.2 Project Management

Many factors contribute to the successful completion of any research project. Three of the most important ones are:

- to have a clear understanding of what you are aiming to achieve,
- to have a clear picture of the tasks that have to be completed,
- to have a clear timetable for completing the tasks.

Clearly defined goals and adequate time planning are therefore vital. Students frequently underestimate the time required for the execution of project work, especially for good data presentation and for writing up.

To help you start out in the right direction, the supervisors normally require the following of you: by the end of the first or the second week after being allocated a project with a supervisor, you should (a) prepare a statement of the general overall aim and specific objectives of the project and (b) construct a time plan for the first semester's project activities. Discuss these with your supervisor at the initial weekly supervision meetings and modify them if necessary. You are required to develop your own work plan for the second semester for inclusion in your Interim Report.

Make sure that you are clearly aware of published submission dates and other deadlines given in Section 1.4 and plan your work so that you meet them.

3.3 Supervision Meeting Record Form

You will be required to keep a Supervision Meeting Record during the course of your project by using the Supervision Meeting Record Form (Appendix 1). The meeting record serves as a proof of engagement with supervision and an indication of progression on the Research Project. The Forms recording the meetings of Autumn Semester will be submitted to **ABEE3036 Moodle** at the end of Autumn Semester. The Module Convenor will use these forms to identify non-engaging research project students and where necessary, advice and/or intervention will be provided to get these students back on track before it is too late. The Forms recording the meetings of the whole project period will be submitted to **ABEE3036 Moodle** towards the end of Spring Semester to aid the marking of Continuous Assessment.

3.4 Project Content

Each project will be different in detail, but most will involve the following stages:

- Review of previous relevant work/literature and broad definition of the aim and objectives of the current project;
- Preparation of work plan for autumn semester;
- Familiarisation with appropriate test methods, existing equipment, computer software etc. to be used in executing the project;
- Planning of the main test/research programme;
- Writing the Interim Report.

The work listed above should be completed entirely within Autumn Semester except the literature review task. Literature review should continue until the end of project period. New publications are emerging all the time and your understanding of the relevant literature improves within the project period, which means it is worthwhile for you to revisit the publications that you have read at the initial stages of the project.

- The main test/research programme, including the analysis of results and any necessary developmental iterations or repeated measurements - this phase of the work will be carried out mainly in the Spring Semester. However, you are strongly advised to start as soon as possible (preferably before the end of the year) to minimise the disruption and loss of momentum caused by the Christmas break and the Autumn Semester assessments.
- Writing-up the project Final Report: You should start the drafting of the Final Report as soon as you can and make sure that you have completed most of the Draft Final Report and submit it to your supervisor by the deadline specified in Section 1.4. You can use the remaining weeks before final submission to amend/improve your Final Report, taking account of the feedback given by your supervisor on the Draft Final Report, write any missing parts and finalise the Final Report in advance of the deadline in May 2025.

3.5 Work Load

The Research Project carries 30 credits spreading equally over two semesters. You are therefore expected to **spend one quarter of your working hours on project related work during the whole academic year**.

CHAPTER 4 PREPARATION OF INTERIM AND FINAL REPORTS

4.1 Introduction

This chapter gives guidance on how to prepare the reports that you will be required to hand in near the end of Autumn and Spring semesters. You should write your report using **the past tense**. Select a font that is easy to read and pick a font size large enough to read with ease: **12 point is the preferred size**. Although you are not required to submit hardcopy reports, you should follow the format guidelines given below carefully in case hardcopy reports are needed for some occasions, e.g. exam board meetings and manual marking.

4.2 Format for Reports

Reports are an important method of communicating the results from work that you have carried out to other researchers who may wish to build on it (or in the case of your project, mark it). A standard format for reports has evolved, the aim of which is to make it easy for others to assess quickly whether your work is relevant to their own and if so to get an accurate picture of what you did, how you did it and what results you obtained. British Standard BS4811 [3] provides guidance on how to structure reports, however, companies and institutions will often have their own in-house style, usually based around the format laid out in the Standard. **To save you poring over the Standard, this document has been written in the style that you will be expected to adopt for your reports.** Notes have been added throughout the document drawing your attention to important features and explaining why they are required. To make it easy to identify the notes, they have been typed in a different font from the main text and appear inside the symbol shown in Fig. 4.1.

Figure 4.1 Format of guidance notes used in this report

4.3 Overall Structure of the Final Report

There are certain key features that your Final Report should contain. They are the *Cover Page*, *Preface*, *Main Text*, and *References*.

4.3.1 Cover Page

This should give the *title* of the project, the *name* of the person who carried it out and the *date* when the report was written. For Nottingham University dissertations there is also a short *declaration* that identifies the report as a piece of assessed coursework.

4.3.2 Preface

The *Preface* provides a map of the report. It should contain an *Abstract* that succinctly summarises the work in terms of 'motivation, aim/objectives, methodology, results, and conclusions', an *Acknowledgement* of any assistance you may have received and a *List of Contents* listing the chapter titles, the sections within each chapter and the page on which each starts. If you have used any, then there should also be a *List of Figures* and a *List of Tables*. These should give the figure/table, number, the title and the page on which it appears.

Finally, in scientific and engineering reports there will often be a *Glossary of Symbols*, which defines the meaning of any symbols used in equations etc. If many acronyms are used in your report, adding a list of acronyms to the preface will help the readers to more easily understand the acronyms when they are reading your report.

4.3.3 Main Text

This will be the largest section of the report and should contain the chapters highlighted below in bold. The number of chapters and their titles will be determined by the nature of the project, but those given below are typical of those you might find in a scientific/engineering research project report.

- **Introduction** which introduces the general background, problem statement, need/motivation for the research, aim and objectives etc.
- **Literature review** which normally describes the wider context of the research problem, reviews the relevant previous studies including their key findings and summarises the knowledge gaps etc.
- **Methodology** which may include the description of the relevant theory, experimental setup and procedures, data processing methods, case studies, and simulation software setup etc.
- **Results and discussion**
- **Conclusions and recommendation for future research.**

4.3.4 References

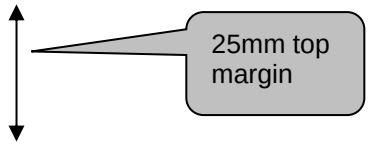
Research often builds on the work of others. When writing a report it is therefore normal to include a literature review section, describing the state of the art in your particular research field. This will usually refer to books, peer-reviewed journal papers, and reports etc. on the subject. For example the reference cited in Section 4.2 would allow you to find the British Standard on the presentation of scientific reports and learn more about it.

Section 1.7 highlighted the importance of correctly referencing any material that is not your own if you propose to include it in your report. Failure to do so could lay you open to claims of plagiarism and result in action being taken against you by the University.

Material that has been lifted directly from another source should be enclosed in quotation marks and referenced. For example if I were writing a report on modern architecture, then to avoid any confusion about my talents as an architectural historian the following passage taken from a book on the history of architecture [4] has been identified and enclosed in quotation marks:

"These monumental structures subtly proportional on Le Corbusier's Modular system function impeccably as 'machines for living in' and belong, without any doubt, to the grandest architectural creations of this century" [4].

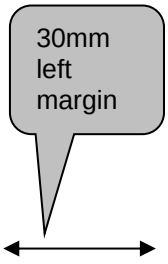
You should also take care to ensure that graphs, charts, diagrams, photos, data etc., taken from other sources (journal papers, scientific reports, websites etc.) are referenced. Appendix 3 in this document gives advice on how to reference material in the main body of the report and how to compile the list of **References** that should appear after the Conclusions and recommendation for future research chapter. All of the listed references should be cited by the report and all of the cited references should be included in the list of References. **A**

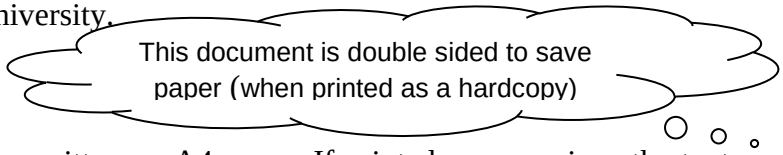


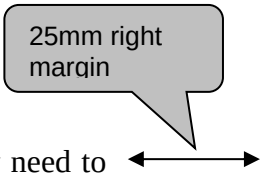
'Bibliography' is not required for the Interim Report or the Final Report and should not be used as the substitute for the section of 'References'.

4.3.5 Appendices

Depending on the nature of your project you may wish to include material as an appendix. Examples might be extracts from manufacturers' catalogues from which data were obtained for the work or derivations to equations presented in the main text. A simple rule to bear in mind when deciding to include an appendix *is does the material improve the clarity of the report?* If it does not then you are probably best to leave it out. The appendices have been used in this document to include relevant forms and to draw your attention to useful guides available from the University.





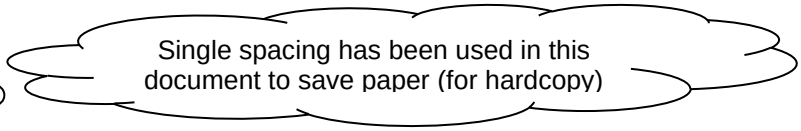


4.4 Page Layout

Your report should be written on A4 paper. If printed, on occasions the text may need to appear on one side of the page only, for example, the supervisor or marker may need to use the blank side of each page to make long comments and/or additional illustrations.

4.4.1 Margins

The margins of the report provide useful space for your Supervisor or marker to jot comments about the text. For this reason, aim to have a 25mm wide right margin and a 30mm wide left margin. The extra width of the left margin is to allow for the area of page that is "lost" when the document is bound. The top and bottom margins should be 25mm wide.



4.4.2 Line Spacing

The main body of your report should be written using 1.5 (lines) spacing between the lines of text. This makes it easier to read the report and also provides space to manually or electronically jot comments, highlight spelling and grammatical mistakes etc. The Preface, References and Abstract sections may be written using single space text.

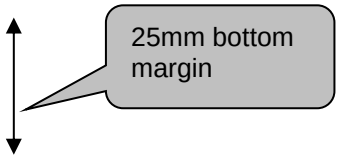
4.4.3 Font Size and Paragraph Formatting

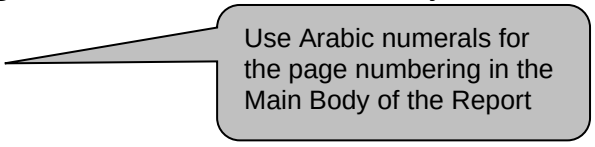
Although the Font of 'Times New Roman' or 'Arial' is preferred, other popular fonts (e.g. Calibri and Verdana) are also acceptable with the minimum font size of 11 (size 12 is preferred). The preferred paragraph format for formal report writing is to have fully justified text. As an example, most of the paragraphs in this document are fully justified. The only exception is this Section (4.4.3) which has been deliberately formatted using left hand justification, sometimes referred to as "ragged right". This can result in a document that is easier on the eye. Irrespective of what format you use, ensure that you remain consistent throughout the report.

4.4.4 Page Numbering

It is important to number the pages in your report. This provides the primary means for others to navigate around the report using the List of Contents in the Preface.

Page numbering should appear at the bottom centre of each page. It is normal to use Roman numerals for the Preface and Arabic numerals for the Main Body of the text. The numbering in the main body of the text is usually run through into the References section. If you have





included appendices then using a system such as A1.1, A1.2… A1.n for Appendix 1 and A2.1, A2.2… A2.n for Appendix 2 etc., is a possible way of dealing with the page numbering.

4.5 Section Numbering

When you write your report, you may wish to refer the reader to other sections of the document to avoid having to duplicate sections of text. This linking together of the material in different chapters is often the sign of a well-written report. In order to allow the reader to find the relevant section quickly, it is usual to use some form of numbering system. You will see from this chapter that all the section numbers begin with a 4 to identify the chapter in which they appear. The second digit relates to the position of the section within the chapter. For example, this section is the fifth in this chapter. The use of section numbers in conjunction with the Contents page allows the reader to navigate about your report quickly and find the relevant information with ease.

Sections 4.3 and 4.4 have been further divided into subsections to provide greater clarity. For short reports, such as those you will produce for the Research Project, it is not necessary to further subdivide the sections. To do so will probably start to detract from the clarity of the presentation and make the report more difficult to read.

4.6 Figures

Most reports contain some figures. These can be graphs, diagrams, photos etc. but all of them should be called ‘figures’. Each figure should have a *figure number* and a *title* that clearly explains what it is. The first digit in the figure number should relate to the chapter in which the figure appears. The second digit should run sequentially from any previous figures that appear in the same chapter. **It is also important that the figure is referred to somewhere in the accompanying text**. For example, Figure 4.2 has been included for illustrative purposes and is a pictorial representation of what you may have been thinking about the Research Project prior to reading this guide.

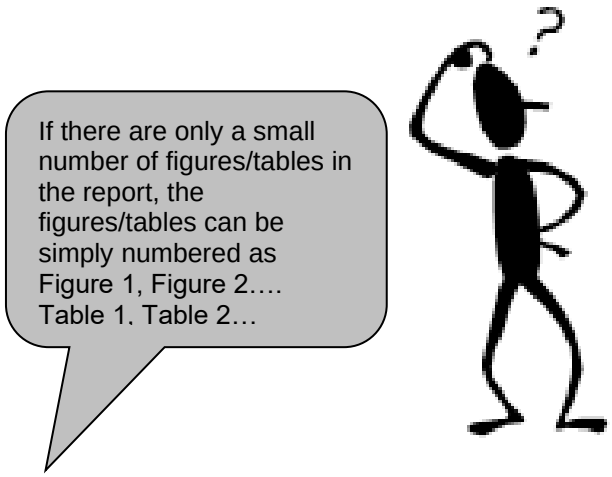


Figure 4.2 Pictorial representation of how you may have viewed the Research Project prior to reading the Project Guide

If this document has served its purpose, then after having read it, most students should be much clearer about what they need to do to complete a good Research Project. The general mood might be represented pictorially by the sketch in Figure 4.3.

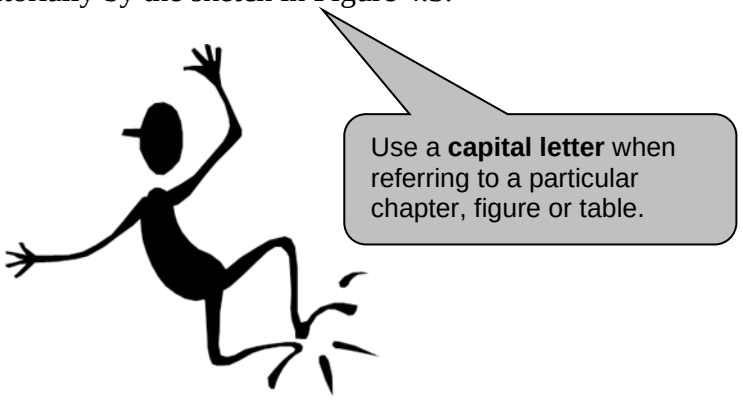


Figure 4.3 Pictorial representation of how you will view the Research Project if the Project Guide has been well written

The use of these two figures illustrates some additional points. It is usual to include the figure shortly after reference has been made to it in the text. The figure may appear embedded in the text or may be inserted on a separate page, following the one where reference is made to it, as with Figure 4.3. **All figures should be discussed/referred to in the text of the report**.

The *title* of the figure and the *figure number* should appear in the *List of Figures* in the *Preface* giving the page on which it appears.

4.7 Tables

As with figures, tables should appear in the report shortly after they have been first discussed in the text. They should be given a table number that relates to the chapter in which they appear and their position relative to other tables in the same chapter. There is an example of a table in Chapter 1. Table 1.1 contains text, however, tables can also contain data, equations etc. The table details (table number, title and the page on which it appears) should be given in the *List of Tables* in the *Preface.* **All tables should also be discussed/referred to in the text of the report**.

4.8 Equations

If you include any equations in your report, ensure that you define the symbols used. There are several ways of doing this. One method is simply to present the equation in the text without defining the symbols locally. For example the natural frequency of a mass on a spring is given by:

$$f_n = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \tag{4.1}$$

The reader would then have to check the *Glossary of Symbols* in the *Preface* of the report to find out what the symbols and their units are. However, if your report contains a large number of symbols, this method is not recommended.

An alternative method is to provide some of the information in the accompanying text. For example, the power, *W*, dissipated by an electrical device is given by

$$W = VI \tag{4.2}$$

where *I* is the current flowing through it and *V*, is the voltage drop across it.

Finally it is possible to list the symbols and their units after defining the equation. For example Young's modulus may be defined as,

$$E = \frac{\sigma}{\gamma} \tag{4.3}$$

where: E = Young's modulus (N/m^2)
σ = stress (N/m^2)
γ = strain (dimensionless)

No matter what method you adopt, it is a good idea to provide a *Glossary of Symbols* in the *Preface* to the report, just in case some of the symbols are omitted from the text.

Equations often need to be referred to or discussed in the report; therefore, they should be numbered, identifying which chapter they belong to and their position relative to other equations in the same chapter. When referring to an equation it is usual to abbreviate the word equation to Eqn. For example, Eqn. (4.1) allows you to predict the natural frequency of a mass-spring system.

4.9 Structure of the Interim Report

The purpose of the Interim Report is to give a concise summary of what has been achieved during the **Autumn Semester** and to present the programme of work that is planned for the **Spring Semester**. It is as much an aid to planning your own work as it is for your Supervisor/Moderator to assess your progress. It should contain the following sections:

- Title page
- Abstract
- Other preface pages
- Main body (introduction, literature review, methodology, preliminary results and discussion, conclusions, a summary of the remaining work for Spring Semester etc.) **which needs to be within the word limit of 1500 – 2000 words**
- Detailed work plan for Spring Semester (Gantt chart)
- References
- Appendices (if any)

Formats for the preface, page layout, section numbering, figures, tables and equations etc. should follow those described above for the Final Report.

CHAPTER 5 CONCLUSIONS

5.1 Introduction

The conclusion chapter should briefly restate the aim and objectives of the project. It should summarise what has been achieved and present the important conclusions reached.

5.2 Recommendations for Further Research

You may wish to include suggestions for further research in your **Final Report**. The suggested future research can be based on the findings of your project and/or the limitations which you have realised your work has at the end of project period. In this case, your conclusion chapter may be titled as 'Conclusions and Recommendations for Further Research'.

Word Count (the main part of the report): 10988 words

Add the word count information on the last page of the main report (above the list of references).

References

1 University of Nottingham. *Intellectual Property Rights*. https://www.nottingham.ac.uk/fabs/research-innovation/ipcommercialisation/aboutintellectualproperty.aspx. (Accessed on 27 Sept 2023)

2 University of Nottingham. Quality Manual. https://www.nottingham.ac.uk/qualitymanual/assessment-awards-and-deg-classification/pol-academic-misconduct.aspx. (Accessed on 27 Sept 2023).

3 BS4811:1972 (Reaffirmation Notice, May 15, 2020). *Specification for the Presentation of Research and Development Reports*. British Standards Organisation.

4 W. Pehnt, ed., *Encyclopaedia of Modern Architecture.* London, Thames and Hudson, 1963.

Appendices

Appendix 1: Supervision Meeting Record Form

Appendix 2: Form of Choices for Projects/Supervisors (BEng Research Project – ABEE3036)

Appendix 3: How to cite references

Appendix 1

Supervision Meeting Record Form*

Student ID and Name:	
Supervisor:	
Research Project Title	

Research Ethics
I have reviewed my Research Project scope and plan in collaboration with my supervisor and come to the following conclusion:
☐ Ethics approval **is not** required
☐ Ethics approval **is** required, and I will include evidence of this being granted in my Research Project Final Report (in Appendix).

Risk
I have reviewed my Research Project scope and plan in collaboration with my supervisor and come to the following conclusion:
☐ A formal risk assessment **is not** required.
☐ Existing risk assessments and safe working procedures will be followed.
☐ I must complete a risk assessment and develop safe working procedures in collaboration with my supervisor and others (e.g., laboratory technician/supervisor), and I will provide evidence of these in my Research Project Final Report (in Appendix).

Meeting Date	**Keywords of the Supervision Meeting**	**Supervisor/Co-supervisor (names)**
End of Semester 1: Signature of student & date		
End of Semester 1: Signature of supervisor & date		
End of Semester 2: Signature of student & date		
End of Semester 2: Signature of supervisor & date		

* The form needs to be signed before each submission.

Appendix 2

Form of Choices for Projects/Supervisors (ABEE3036) - 2024/2025			
Student Name:			
Student ID Number:			
	Project No. & Title	**Project Supervisor**	**Comment***
First Choice			
Second Choice			
Third Choice			
Fourth Choice			
Own Research Project (title, brief aim/objectives)		**Preferred supervisor**	**Comment***
(1) Deadline of submission to Moodle: 3:00pm, Friday, 11 Oct 2024			
(2) You are strongly advised to choose projects provided by different supervisors			
(3) You are also strongly advised to fully use your 4 choices.			
*** Add any comment that you would like the module convenor to consider when allocating the projects**			
e.g. 'Choice No.3 could be Choice No. 2'; 'My preferred projects are those of simulation based' etc.			

Appendix 3: Referencing

(1) A list of **references** is required for the Interim/Final Report.

(2) All listed references should be cited in the text.

(3) All cited references should be listed in the 'References'

(4) How to cite references: see the link below on referencing

https://www.nottingham.ac.uk/studyingeffectively/referencing/referencing/index.aspx

(5) Websites can be cited as 'references': see the link below on referencing websites https://www.nottingham.ac.uk/studyingeffectively/referencing/referencing/websites/index.aspx

(6) A '**Bibliography**' is not required for the Interim/Final Report.

(7) A '**Bibliography**' **should not** be used as a substitute for the list of references.