Prifysgol Wrecsam
Wrexham University

ASSIGNMENT BRIEF

Module title	Electrical and Electronic Engineering Systems Modelling and Simulations
Module code	ENG778
Module leader	Dr. Mobayode. O. Akinsolu
Assessment title	Numerical Analysis and Model-based Design Challenges in Electrical and Electronic Engineering
Launch date	October 17, 2025.
Submission deadline	January 16, 2026.
Expected date for the return of marks and feedback	Feedback can be expected within 3 weeks of the submission date and might be electronic via email or Moodle, written, verbal, or a combination of these.
Module outcomes assessed	1. Apply computer modelling and analysis to the solutions of practical electrical and electronic design problems. 2. Apply and identify the key stages associated with utilising design specifications and parameters in performing simulation-based modelling and characterisation of electrical and electronic engineering systems. 3. Demonstrate proficiency in the use of and an ability to produce representative models of electrical and electronic engineering systems with proprietary numerical modelling tools or platforms.
AHEP4 LOs	M1, M2 & M3 AHEP4 Document
Assessment weighting	100%
Word count (if relevant)	Word Count: 5,000 words (+/- 10%) (Comprehensive details of all in-class and real-world problems addressed). Please, as far as possible, avoid sheepish copying of the problem questions and example codes from the laboratory sessions into your reports; this will only lead to having a high similarity Turnitin index in your reports.
Assessment task details - provide a description of the task	

The following in-class tasks are to be completed and reported on:

Problem 1 (a) (About 250 Words)

Mathematical Modelling of Physical Systems

Using a numerical computing and model-based design environment (MATLAB and Simulink), complete the following tasks:

1. Analyse and solve the following equations for physical systems. Show and comment on the plots of the solutions for "ode23" and "ode45" indicating the solver used for each solution by annotating your plots:

$$\frac{\delta y}{\delta t} = t^2; y(0) = 1 \; and \; 0 \le t \le 10$$
$$\frac{\delta y}{\delta t} = \frac{t^2}{y}; y(0) = 1 \; and \; 0 \le t \le 5$$
$$\frac{\delta y}{\delta t} + \frac{2y}{t} = t^4; y(1) = 1 \; and \; 1 \le t \le 8$$

2. In engineering dynamics, the Van der Pol oscillator is a non-conservative oscillator with non-linear damping. It evolves in time according to the following second-order differential equation:

$$\frac{\delta^2 x}{\delta t^2} - \mu(1 - x^2)\frac{\delta x}{\delta t} + x = 0$$

   Where x is the position coordinate, which is a function of the time t, and μ is a scalar parameter indicating the nonlinearity and the strength of the damping.

   Assuming a damped system ($\mu = 1$), solve the homogeneous second-order ordinary differential equation of the system over a time interval of 0 s to 25 s (that is, $t \in [0, 25]$) with the initial values of 0 and 2.5 for $x(0)$ and $x'(0)$, respectively. Show and comment on the plots of your solutions and indicate the "ode" solver(s) used by annotating your plots.

Problem 1 (b) (About 150 Words)

Mathematical Modelling of Physical Systems

For the following difference equations, derive the transfer functions, specify, and analyse the difference equations in a numerical computing and model-based design environment (MATLAB and Simulink) using codes, mathematical blocks, and models:

$$y[n] = 3x[n] + y[n-1]$$

$$y[n] = 2x[n] + 3x[n-1] + x[n-2]$$

Problem 2 (About 1,500 words)

Simulation of Bimetallic Strip Behaviour for Temperature-Control Applications

Background and Introduction

In its basic form, a bimetallic strip is a transducer that converts a temperature change or gradient (heat energy) into mechanical displacement (mechanical energy). It usually consists of two strips of different materials or metals which expand at different rates when heated, owing to different coefficients of expansion. Some common configurations include, but are not limited to, steel and copper, steel and brass.

In a bimetallic strip, the strips are usually of equal dimensions and are joined throughout their length by riveting, brazing, or welding. When heated the bimetallic strip bends in a particular way, and it bends in the opposite direction if cooled below its initial temperature. It is good to note that the metal with the higher coefficient of thermal expansion is on the outer side of the curve when the strip is heated and on the inner side when it is cooled, as shown in Figure 1 (a configuration for brass and steel).

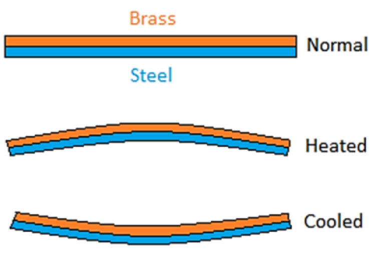

Figure 1. Curvature of a typical bimetallic strip.

From Figure 2, analytically, the curvature k of the bimetallic strip is related to its material properties and dimensions as follows [1]:

$$k = \frac{6E_1E_2(h_1+h_2)h_1h_2\epsilon}{E_1^2h_1^4 + 4E_1E_2h_1^3h_2 + 6E_1E_2h_1^2h_2^2 + 4E_1E_2h_2^3h_1 + E_2^2h_2^4} \qquad (1)$$

where E_1 and h_1 are the Young's modulus and height (thickness) of the material or metal one, respectively, and E_2 and h_s are the Young's modulus and height (thickness) of material or metal two, respectively.

ϵ is the misfit strain evaluated as follows:

$$\epsilon = (\alpha_1 - \alpha_2)\Delta T$$

where α_1 is the coefficient of thermal expansion of the material or metal one, α_2 is the coefficient of thermal expansion of the material or metal two, and ΔT is the current or final temperature minus the reference or initial temperature (the temperature where the beam has no flexure).

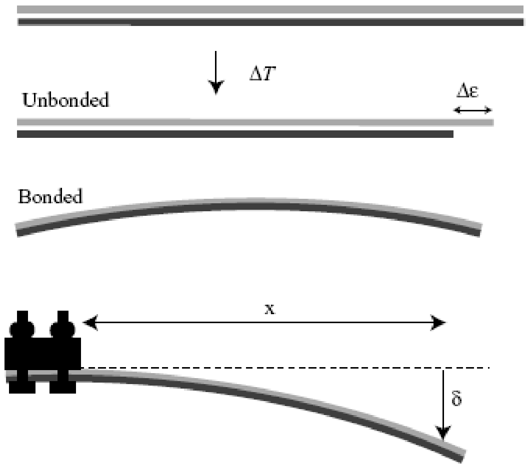

Figure 2. Theoretical derivation of the curvature of a typical bimetallic strip.

At thermal equilibrium, the resulting curvature, k, (reciprocal of the radius of curvature), is related to the displacement, $> \delta$, and the distance, x, along the strip at which the displacement is being measured by the relationship [1]:

$$k = \frac{2\, sin\left[tan^{-1}\left(\delta/_x\right)\right]}{\sqrt{(x^2+\delta^2)}} \qquad (2)$$

Investigate, design, and model a bimetallic strip using an appropriate CAD tool (ANSYS Workbench) for use in a typical electrical and electronic engineering system of your choice. At the very least, your work must include or reveal the following design specifications and/or functional requirements (there must be sound scientific and engineering justification for all decisions):

2. Geometry and dimensions of the bimetallic strip
2. Engineering data and material composition of the bimetallic strip and its riveting.
   a. Note that the riveting or welding, or adhesive between the two strops must be clearly accounted for (even if it is assumed to be perfect and/or negligible in your model).
3. Analysis of the bimetallic strip under various temperature conditions.
4. Comparison of simulation results with analytical results using applicable standard relations. That is, a comparison between the analytical value of k in equation (1) and its derived value in equation (2) based on results from your simulations.
5. Real-world contextual electrical and electronic engineering application(s) for the design and model of the bimetallic strip.

Advanced or Optional Requirements

1. Studying the bimetallic strip under various geometrical profiles and material properties by interfacing your CAD tool with a numerical analysis and computing tool (e.g. MATLAB) to vary geometric values and material properties.
2. Extraction and comparison of results for various geometrical designs and material properties by interfacing your CAD tool with a numerical analysis and computing tool (e.g. MATLAB).

There must be a sound scientific, technological, engineering, and mathematical justification for all decisions. All assumptions must be tractable and clearly stated. All data and information sources must be properly cited and/or referenced.

Reference

University of Cambridge, UK, *The Bi-material Strip*, [Online], Available at: https://www.doitpoms.ac.uk/tlplib/thermal-expansion/bimaterial-strip.php

Report Requirements

- All equations, figures, and tables must be clearly numbered and referenced within the text.
- All variables must be clearly defined on first use.
- Any code developed must be fully commented and included in an appendix.
- Proper academic referencing (IEEE style) must be used throughout.

Real-world Electrical and Electronic Engineering Design Challenges

(Group Tasks)

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Problem 3 – Design Challenge I (About 1,500 Words)

Design, Modelling, Simulation and Characterisation of an Electrical and Electronic Engineering Device

Task Description

Using a model-based design and simulation environment such as MATLAB/Simulink/Simscape, you are required to investigate the design, modelling, simulation, and characterisation of a power inverter unit suitable for both a single-phase domestic supply and a three-phase industrial supply within the UK context. You must then produce a concise technical report documenting your work.

At a minimum, your completed task should include:

- *Background and Principles*
    - A description of the fundamental working principles of inverters, including their operation, significance, and present-day applications in domestic and industrial settings within the UK.
- *Voltage Input*
    - Appropriate schematics, supported by analysis and discussion based on simulations. Consider the characteristics of single-phase domestic input and three-phase industrial input supplies.
- *Use of Silicon-Controlled Rectifiers (SCRs) and Load Connection*
    - Relevant schematics, analysis, and simulation-based discussion of SCR applications.
    - Explanation of load connection strategies for both single-phase and three-phase inverter configurations.
- *Voltage Output*
    - Schematics, analysis, and simulation-based discussion of the inverter's voltage output.
    - Consideration of waveform quality, harmonics, and suitability for practical applications.
- *Limitations and Recommendations*
    - Critical discussion of the limitations of your designed or modelled inverter system.
    - Technical recommendations for improvement, including suggestions for further testing, validation, and refinement to support potential product development and future commercial deployment.

Report Requirements

- All equations, figures, and tables must be clearly numbered and referenced within the text.
- All variables must be clearly defined on first use.
- Any code developed must be fully commented and included in an appendix.
- Proper academic referencing (IEEE style) must be used throughout.

Problem 4 – Design Challenge II (About 1,500 Words)

Design, Modelling, Simulation and Characterisation of an Electrical and Electronic Engineering System

Task Description

Using a model-based design and simulation environment such as MATLAB/Simulink/Simscape, you are required to design, model, simulate, and analyse a hybrid Distributed Energy Resource (DER) system suitable for a remote or isolated location of your choice anywhere in the world (other than the example shown in the class). Your system should integrate at least two different renewable distributed energy resources (e.g., wind, solar PV, micro-hydro, biomass, battery storage, hydrogen storage) and demonstrate how these can collectively supply reliable, cost-effective, and sustainable power to meet the location's demand profile.

You must also provide a critical technical report describing your methodology, findings, and recommendations.

Task Completion Requirements

Your completed task must include the following elements:

- *Background and Context*
  - Provide an overview of the selected remote location (e.g., geographical conditions, climate, existing energy challenges).
  - Justify why a hybrid DER solution is suitable.
- *System Modelling and Design*
  - Develop schematic diagrams of the proposed hybrid DER system.
  - Explain design assumptions (e.g., load demand, renewable resource potential, component sizing, efficiency factors).
  - Identify and justify the choice of DER technologies.
- *Simulation and Analysis (MATLAB/Simulink/Simscape)*
  - Model the operation of the hybrid DER system in MATLAB/Simulink/Simscape.
  - Include supply–demand balancing, voltage/frequency stability, and islanded vs grid-connected modes (if applicable).
  - Assess power quality, energy reliability, and system resilience.

- *Performance Evaluation*
  - Analyse energy yield, demand coverage, storage utilisation, and curtailment levels.
  - Evaluate the system's technical and operational limitations.
- *Economic and Environmental Assessment*
  - Provide a basic cost analysis such as payback period.
  - Estimate environmental impacts (e.g., CO_2 emissions avoided compared to diesel-only generation).
- *Recommendations*
  - Suggest improvements for system optimisation and scalability.
  - Discuss the potential for further testing, pilot deployment, and commercialisation.

Report Requirements

- All figures, tables, and equations must be clearly numbered and referenced.
- Variables must be defined on first use.
- Simulation codes must be commented and provided in an appendix (not included in the word count).
- Proper academic referencing (IEEE style) must be used throughout.

Submission instructions - What should be the format of the submission? / Where should it be submitted?

In your report, all codes must be clearly commented, all plots must be properly annotated and all results (particularly, plots or graphs, block models, mathematical equations, or relations) must be discussed.

The report must not exceed a total of 30 pages, including the title and declaration pages. Addenda such as datasheets, standards, codes, and so on can be provided as appendices to the main report.

Complete your report in neatly justified Arial or Times New Roman font size of 12 on A4 paper size. Your submission must be in a single document (.doc or .pdf) having a title and a declaration. The title must have your full name, student ID number, module title, and date. The declaration must include a statement affirming that you have completed the coursework independently with your name, signature, and date under the statement.

NOTE:

Late submissions will be duly penalized. This is an independent coursework. Presentation of other people's work as your own is a serious academic misconduct *that will be sanctioned in accordance with regulations, policies, and procedures at Wrexham University. Please refer to the Student Guide for more details.*

Where a student fails to submit coursework for summative assessment (including all components and elements) by an appointed time and by the appointed method for reasons other than those deemed by the Extenuating Circumstances Panel as constituting extenuating circumstances, the following penalties shall be applied:

- *Up to five working days late, the work will be marked but the maximum mark awarded will be 40% or an equivalent pass grade.*
- *More than five working days late, the work will be awarded zero and the student will be deemed to have failed that assessment.*

(Academic Regulations Section 3 Para 5.2.1)

<u>All submission via Moodle Turnitin Only</u>

All submitted work is expected to observe academic standards in terms of referencing, academic writing, use of language etc. Failure to adhere to these instructions may result in your work being awarded a lower grade than it would otherwise deserve.

Generative Artificial Intelligence (GenAI) Guidance

Clearly explain what use of GenAI is permitted within the assignment e.g.

- *Assessment tasks that actively encourages and embraces GenAI as part of the work (be explicit as to how)*
- *Assessment tasks in which students may use GenAI to assist them (be explicit as to how)*
- *Assessment tasks in which the use of GenAI would not be appropriate*

Guidance as to how GenAI use might be permitted is available on the Learning and Teaching Hub

Hint(s) and Tip(s)

Please refer to the in-class tasks and exercises from the Laboratory sessions.

For example:

See the lecture note on use of “ode23” and “ode45” solvers in MATLAB for addressing 1st order and 2nd order differential equations.

See the design of digital filters using Z-transform and difference equations.

See the lecture video on how to design a simply supported beam in Ansys.

See the lecture note on full-bridge rectifier.

See the lecture note on SCRs.

See the lecture note on hybrid DER proposal for a remote island.

Marking and Moderation

A breakdown of the marking scheme is shown below, and a more detailed explanation of grades and competencies is included on the last page this assignment brief.

Marking Scheme for Report: LOs 1, 2 and 3 (Weighting: 100%)

Problem 1: (a) and (b)	Codes and Comments	5%
	Plots and Annotations	5%
	Results and Discussion	5%
Problem 2	Design and Modelling	10%
	Analysis and Discussion	10%
	Conclusions and Recommendations	5%
Problem 3	Design and Modelling	10%
	Analysis and Discussion	10%
	Conclusions and Recommendations	5%
Problem 4	Design and Modelling	10%
	Analysis and Discussion	10%
	Conclusions and Recommendations	5%
Structure		5%
Presentation		5%
TOTAL =		100%

1st marking will be by Module Tutor, internal verification will be by an appropriate member of the academic team.

The external examiner will have an opportunity to sample the work prior to the academic board.

Employability Skills Applied

On successful completion of this module, a student will have had opportunities to demonstrate achievement of the following Employability Skills;

Tick all that apply.	
Adaptability & Flexibility *(Managing Change, Coping with Ambiguity, Transferable Skills)*	✓
Career Development *(Career information, Access to opportunity, Career readiness)*	✓

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Critical Thinking *(Problem Solving, Analytical Skills, Critical Thinking)*	✓
Digital Capabilities *(Digital Tools & Software, Data Analysis, Digital Citizenship)*	✓
Enterprise and Entrepreneurship *(Innovation, Commercial Awareness and Influencing)*	✓
Interpersonal Skills *(Communication, Emotional Intelligence, Networking, Bilingualism)*	✓
Personal Skills *(Initiative, Leadership, Social intelligence)*	✓
Resilience *(Positive Mindset, Self Awareness, Motivation & Purpose)*	✓
Social Impact and Sustainability *(Social Responsibility, inclusivity, Cultural Awareness and application of the UN Sustainable* development goals)	✓
Teamwork *(Collaboration Skills, Active Listening, Planning & Organising)*	✓

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ASSIGNMENT FEEDBACK

NB All marks are provisional until confirmation by the Awards/Progression Board

Feedback Against Learning Outcomes / Criteria:	**Comments**	**Mark**
	Total Mark	
Areas of good Practice:		
Areas for Improvement:		

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Assessment Rubric

Grade Boundaries %	0%	1-29%	30-39%	40 – 49%	50 – 59%	60 – 69%	70 – 79%	80 – 90%	90-100%	**Total**
Learning outcome:	Non-submission (No work submitted. Learning outcomes and criteria have not been addressed.)	Unsatisfactory	Minimum	Satisfactory	Good	Very good	Excellent	Exceptional	Outstanding	
1. Apply computer modelling and analysis to the solutions of practical electrical and electronic design problems.		Does not apply computer modelling and analysis to solutions of practical electrical and electronic design problems. Work is missing or fundamentally incorrect; models are absent or irrelevant; calculations, assumptions and validation are not provided.	Attempts to apply computer modelling and analysis, but choices are inappropriate or seriously flawed. Very limited link to practical electrical and electronic design problems; results are largely unreliable; little or no research support.	Basic application of computer modelling and analysis to straightforward practical design problems. Some correct steps but with gaps in reasoning, weak parameter choices and minimal validation; scant referencing.	Competent application of computer modelling and analysis to typical practical design problems. Assumptions are stated; parameters are mostly suitable; results are plausible with some checking (e.g., hand-calc or data sheet comparison).	Consistent and accurate application of computer modelling and analysis to non-trivial practical design problems. Demonstrates awareness of current issues/constraints; performs sensitivity or uncertainty checks; draws on appropriate sources.	Systematic, rigorous application of computer modelling and analysis to complex practical design problems. Integrates research, optimises design trade-offs, justifies modelling choices, and evaluates limitations; clear, well-structured communication.	Highly original application of computer modelling and analysis producing insightful solutions to practical design problems. Explores edge cases, validates with multiple methods/benchmarks, and generalises findings; documentation enables replication.	Authoritative application of computer modelling and analysis that yields elegant, generalisable solutions to practical electrical and electronic design problems. Professional-level validation and presentation; may extend or refine established practice.	
2. Apply and identify the key stages associated with utilising design specifications and parameters in performing simulation-based modelling and characterisatio		Does not apply or identify key stages. Design specifications and parameters are ignored; no credible simulation-based modelling or characterisation of electrical and electronic	Partial attempt to apply/identify key stages, but steps are missing or incorrect. Misreads specifications, selects unsuitable parameters, and produces unusable simulation-based modelling and characterisation.	Identifies some key stages (specification reading, parameter selection, basic setup) and attempts simulation-based modelling and characterisation of the system. Execution is uneven; limited justification and weak record-keeping.	Correctly applies and identifies key stages: interprets design specifications, derives main parameters, plans simulations, and performs basic characterisation of the electrical/electronic system. Reasonable	Clearly applies and identifies key stages end-to-end: requirements capture → parameter derivation → model configuration → execution or simulation run plan → results characterisation. Good traceability	Demonstrates a robust workflow that applies and identifies key stages with strong rationale. Uses tolerances, corners and operating envelopes from design specifications; selects/justifies parameters; executes efficient simulation-based modelling and	Exemplary control of the full lifecycle of applying and identifying key stages. Automates/streamlines setup from specifications to parameters; applies DOE/sensitivity analyses; triangulates characterisation against analytical/measureme	Benchmark standard. Innovates in how key stages are applied and identified; derives reusable templates from design specifications and parameters; conducts rigorous simulation-based modelling and characterisation that could inform organisational best practice.	

n of electrical and electronic engineering systems.		engineering systems.			organisation and reporting.	from specifications to parameters; communicates decisions with diagrams/tables.	characterisation with verification.	nt data; concise, professional reporting.		
3. Demonstrate proficiency in the use of an ability to produce representative models of electrical and electronic engineering systems with proprietary numerical modelling tools or platforms.		Does not demonstrate proficiency with simulation tools; cannot produce representative results for electrical and electronic systems.	Very limited proficiency with simulation tools; setup errors common; outputs are incomplete/inaccurate and not representative of system behaviour.	Basic proficiency: can run simulation tools with guidance and produce some representative results, though coverage, accuracy and labelling are inconsistent.	Solid proficiency: selects appropriate tool features, manages models and data, and produces representative results with basic validation and clear plots/tables.	Strong proficiency: configures models efficiently, uses parameter sweeps and probes, and produces representative, reliable results with uncertainty notes and sensible visualisation.	Advanced proficiency: exploits advanced features (e.g., scripting/automation, convergence control), compares tool outputs with theory/data, and produces highly representative results suitable for decision-making.	Expert proficiency: builds robust, reusable models; ensures numerical stability; documents workflow; produces detailed, traceable and representative results with clear limits of validity.	Mastery: sets standards for proficiency with simulation tools; integrates toolchains; validates against independent sources; produces exemplary, publication-quality representative results that reveal design insights.	
Comments										