

BACHELORS DEGREE ASSIGNMENT SPECIFICATION

Student name:	ARTHURE	Student P number:	
Programme:	BEng Automotive and Manufacturing streams		
Module:	Advanced Stress Analysis & FEA	Module Level (4, 5, 6):	6
Module code:	M6X00420	Contribution to Overall Module Assessment (%):	50 %
Lecturer:	Kelvin Lake	Internal Verifier:	Rob Goodson
Assignment Title:	Can FEA replace physical testing?	Assignment No (x of x):	1 OF 1
Hand Out Date:	25/02/2020	Submission deadline:	29/03/2020

Referencing:	In the main body of your submission you must give credit to authors on whose research your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have read or quoted in order to complete this assignment (e.g. for books: surname of author and initials, year of publication, <u>title of book</u> , edition, publisher: place of publication).		
Disclosure:	I declare that this assignment is all my own work and that I have acknowledged all materials used from the published or unpublished works of other people. All references have been duly cited.		
Student's Signature:	Assignments will not be accepted without a signature here	Date:	
Turnitin: Lecturer to tick to indicate if an electronic version of the assignment must be submitted to Turnitin. Note: the Turnitin version is the primary submission and acts as a receipt for the student. Penalties for late submission: Up to four weeks late, maximum mark of 40%. Over four weeks late, Refer. Only Year Tutors and the Programme Director may grant an extension.			YES
			NO

Learning Outcomes tested (from module syllabus)	Assessment Criteria To achieve each outcome a student must demonstrate the ability to:
Demonstrate an ability to analyse a range of engineering problems using advanced stress analysis principles.	

- DO NOT put this form into Turnitin or it will match many similarities with other students' submissions.

TASK DESCRIPTION

This assignment explores FEA and the role that it plays in product development. It is expected that the student will research this topic (referencing any sources used, using Harvard or Vancouver).

GUIDANCE FOR STUDENTS IN THE COMPLETION OF TASKS



The above image shows a component undergoing physical testing and the corresponding FE model. Your task for this assignment is to discuss the following;

1. Why companies typically carryout FE analysis alongside physical testing.
2. How a physical test may be correlated to an FE model.
3. If you think that FE analysis can (or should) ever replace physical testing.

In order to do this, you should consider a case study and use this to discuss the above tasks.

This report should be 3000 words long and should be submitted via moodle

STRUCTURAL SECTION MARKING CRITERIA AND STUDENT FEEDBACK

This section details the assessment criteria. The *extent* to which these are demonstrated by you determines your mark. The marks available for each criterion are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Common Assessment Criteria Applied	Marks available	Marks awarded
1. Research-informed Literature Extent of research and/or own reading, selection of credible sources, application of appropriate referencing conventions.		
(Assessed in point 1)	30	14.7
2. Knowledge and Understanding of Subject Extent of knowledge and understanding of concepts and underlying principles associated with the discipline.		
(Assessed in point 2)	30	15.9
3. Analysis Analysis, evaluation and synthesis; logic, argument and judgement; analytical reflection; organisation of ideas and evidence		
(N/A)	0	
4. Practical Application and Deployment Deployment of methods, materials, tools and techniques; application of concepts; formulation of innovative and creative solutions to solve problems.		
(Assessed in point 3)	30	16.5
5. Skills for Professional Practice Attributes in professional practice: individual and collaborative working; deployment of appropriate media; presentation and organisation.		
(Assessed in report presentation and structure)	10	5.8

Assignment Mark Overall (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)	Late Submission Penalties (tick if appropriate)		52.9 %
	Up to one-week late		
	Over one week late		

COMMON ASSESSMENT AND MARKING CRITERIA

	OUTRIGHT FAIL	UNSATISFACTORY	SATISFACTORY	GOOD	VERY GOOD	EXCELLENT	EXCEPTIONAL
Assessment Criteria	0-29%	30-39%*	40-49%	50-59%	60-69%	70-79%	80-100%
1. Research-informed Literature Extent of research and/or own reading, selection of credible sources, application of appropriate referencing conventions	Little or no evidence of reading. Views and findings unsupported and non-authoritative. Referencing conventions largely ignored.	Poor evidence of reading and/or of reliance on inappropriate sources, and/or indiscriminate use of sources. Referencing conventions used inconsistently.	References to a limited range of mostly relevant sources. Some omissions and minor errors. Referencing conventions evident though not always applied consistently.	Inclusion of a range of research-informed literature, including sources retrieved independently. Referencing conventions mostly consistently applied.	Inclusion of a wide range of research-informed literature, including sources retrieved independently. Selection of relevant and credible sources. Very good use of referencing conventions, consistently applied.	A comprehensive range of research informed literature embedded in the work. Excellent selection of relevant and credible sources. High-level referencing skills, consistently applied.	Outstanding knowledge of research-informed literature embedded in the work. Outstanding selection of relevant and credible sources. High-level referencing skills consistently and professionally applied.
2. Knowledge and Understanding of Subject Extent of knowledge and understanding of concepts and underlying principles associated with the discipline.	Major gaps in knowledge and understanding of material at this level. Substantial inaccuracies.	Gaps in knowledge, with only superficial understanding. Some significant inaccuracies.	Evidence of basic knowledge and understanding of the relevant concepts and underlying principles.	Knowledge is accurate with a good understanding of the field of study.	Knowledge is extensive. Exhibits understanding of the breadth and depth of established views.	Excellent knowledge and understanding of the main concepts and key theories. Clear awareness of challenges to established views and the limitations of the knowledge base.	Highly detailed knowledge and understanding of the main theories/concepts, and a critical awareness of the ambiguities and limitations of knowledge.
3. Analysis Analysis, evaluation and synthesis; logic, argument and judgement; analytical reflection; organisation of ideas and evidence	Unsubstantiated generalisations, made without use of any credible evidence. Lack of logic, leading to unsupported/missing conclusions. Lack of any attempt to analyse, synthesise or evaluate.	Some evidence of analytical intellectual skills, but for the most part descriptive. Ideas/findings sometimes illogical and contradictory. Generalised statements made with scant evidence. Conclusions lack relevance.	Evidence of some logical, analytical thinking and some attempts to synthesise, albeit with some weaknesses. Some evidence to support findings/ views, but evidence not consistently interpreted. Some relevant conclusions and recommendations, where relevant	Evidence of some logical, analytical thinking and synthesis. Can analyse new and/or abstract data and situations without guidance. An emerging awareness of different stances and ability to use evidence to support the argument. Valid conclusions and recommendations, where relevant	Sound, logical, analytical thinking; synthesis and evaluation. Ability to devise and sustain persuasive arguments, and to review the reliability, validity & significance of evidence. Ability to communicate ideas and evidence accurately and convincingly. Sound, convincing conclusions / recommendations.	Thoroughly logical work, supported by evaluated evidence. High quality analysis, developed independently or through effective collaboration. Ability to investigate contradictory information and identify reasons for contradictions. Strong, persuasive, conclusions, justifiable recommendations.	Exceptional work; judiciously selected and evaluated evidence. Very high quality analysis, developed independently or through effective collaboration. Ability to investigate contradictory information and identify reasons for contradictions. Highly persuasive conclusions
4. Practical Application and Deployment Effective deployment of appropriate methods, materials, tools and techniques; extent of skill demonstrated in the application of concepts to a variety of processes and/or contexts; formulation of innovative and creative solutions to solve problems.	Limited or no use of methods, materials, tools and/or techniques. Little or no appreciation of the context of the application.	Rudimentary application of methods, materials, tools and/or techniques but without consideration and competence. Flawed appreciation of the context of the application.	An adequate awareness and mostly appropriate application of well established methods, materials, tools and/or techniques. Basic appreciation of the context of the application.	A good and appropriate application of standard methods, materials, tools and/or techniques. Good appreciation of the context of the application, with some use of examples, where relevant.	A very good application of a range of methods, materials, tools and/or techniques. Very good consideration of the context of the application, with perceptive use of examples, where relevant. Evidence of some innovation and creativity.	An advanced application of a range of methods, materials, tools and/or techniques. The context of the application is well considered, with extensive use of relevant examples. Application and deployment extend beyond established conventions. Innovation and creativity evident throughout.	Outstanding levels of application and deployment skills. Assimilation and development of cutting edge processes and techniques.
5. Skills for Professional Practice Demonstrates attributes expected in professional practice including: individual initiative and collaborative working; deployment of appropriate media to communicate (including written and oral); clarity and effectiveness in presentation and organisation.	Communication media is inappropriate or misapplied. Little or no evidence of autonomy in the completion of tasks. Work is poorly structured and/or largely incoherent.	Media is poorly designed and/or not suitable for the audience. Poor independent or collaborative initiative. Work lacks structure, organisation, and/or coherence	Can communicate in a suitable format but with some room for improvement. Can work as part of a team, but with limited involvement in group activities. Work lacks coherence in places and could be better structured.	Can communicate effectively in a suitable format, but may have minor errors. Can work effectively as part of a team, with clear contribution to group activities. Mostly coherent work and is in a suitable structure.	Can communicate well, confidently and consistently in a suitable format. Can work very well as part of a team, with very good contribution to group activities. Work is coherent and fluent and is well structured and organised.	Can communicate professionally and, confidently in a suitable format. Can work professionally within a team, showing leadership skills as appropriate, managing conflict and meeting obligations. Work is coherent, very fluent and is presented professionally.	Can communicate with an exceptionally high level of professionalism. Can work exceptionally well and professionally within a team, showing advanced leadership skills. Work is exceptionally coherent, very fluent and is presented professionally.

Student Self Evaluation Form

Student name:		Student P number:	
Programme:		Year of programme	
Assignment Title:			

This section repeats in brief the common assessment criteria detailed on previous pages. The *extent* to which these are demonstrated by you determines your mark. Using these criteria, tick the box that best indicates the level of achievement you feel you have achieved with regard to each of them.

Common Assessment Criteria Applied	Level of Achievement						
	REFER		3 rd	2:2	2:1	1 st	1 st
	OUTRIGHT FAIL	UNSATISFACTORY	SATISFACTORY	GOOD	VERY GOOD	EXCELLENT	EXCEPTIONAL
1. Research-informed Literature	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐
2. Knowledge and Understanding of Subject	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐
3. Analysis	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐
4. Practical Application and Deployment	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐
5. Skills for Professional Practice	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐

PLEASE COMMENT ON AREAS IN WHICH YOU FEEL THAT YOU HAVE PERFORMED WELL	PLEASE COMMENT ON AREAS YOU FEEL THAT YOU NEED TO DEVELOP

Student's Name		Date	
Student's Signature			

FEA assignment

William Arthure

P149138

Why do companies carryout FE analysis alongside physical testing?

How does a physical test correlate to an FE model?

If you think that FE analysis can or should ever replace physical testing.

Introduction

FEA is a method of testing parts in the design process without needing multiple prototypes to perform each test on. Loads and forces can be simulated to test the part through a computer programme, to make an accurate visual example of the part undergoing testing on the computer screen. This is a method used widely by companies in industry, this report aims to investigate why these companies carryout finite element analysis alongside physical testing.

Why do companies carry out FEA alongside physical testing ?

Finite element analysis is a computer simulation method of analysing any design for products or machinery equipment by undergoing stresses, vibrations, loads and heat transfer. This can find flaws in designs, refine and optimise them before the product is even manufactured for the first time (PES performance, 2020). Some places may use FEA as a standalone method of testing their products, however it is often used alongside the standard physical tests, once the product has been made. The benefit to this is gaining the best of both methods, where the FEA can reduce the amount of physical tests needed and therefore reduce the time taken to tests prototypes of a product.

FEA is most beneficial to making components which require strength, durability and dynamic analysis. It's mainly used to analyse designs and find areas that can be changed to reduce cost, unnecessary weight, manufacturing time or to improve overall performance. It can massively improve a design in its early stages, before having to undertake any physical tests, which could be highly expensive and destructive to the part. A complex computerised modelling software is used in order to create and test the design, simulating movements that would be made by the part if it were being used for its actual purpose. This is done by setting certain parameters in the programme, to gain a realistic understanding of the paces the part would be put through in its real-life setting. (Element, 2020)

FEA is also useful in testing components that are too large for physical testing, once the conditions are calculated for loads and forces an accurate representation of the part undergoing a real test can be made, on a part which is far too big or complex to undertake numerous physical tests on.

Applications of FEA:

- Stress analysis – analysing stresses, strains, failure points and creep
- Thermal analysis – Conduction, convection, radiation
- Vibration analysis – Modal, harmonic, transient, random vibrations
- High impact analysis – long/ short duration simulation

There are many benefits to using FEA alongside physical testing. Some include; early evaluation of design parameters and allowing a design to be enhanced before it is even made. Creating virtual prototypes on the computer, meaning fewer physical prototypes are required which saves a lot of time and also money on materials for the physical products. This means the company using FEA can undertake rapid prototyping, analysing and testing their prototypes in a much shorter time frame. Another benefit to using FEA is the efficiency when in the design stage, rather than having to make the prototype, redesign it and make another numerous times, the design can be tested virtually and then redesigned to its optimal form in much less time, using far less resources and expenses. Due to the lower need for prototypes to be made, an increase in productivity can be seen as the testing process timescale is reduced. Although the price of FEA software and the computers capable of running such programmes may be a lot, it is definitely a profit rising method in the long run when the amount of prototypes being manufactured is drastically cut due to the FEA being able to simulate the tests before manufacture.

Performance of the product can be maximised in the design process in ways which may not have been discoverable in a physical testing only process. For example the computer programmes can push a part to its limit and evaluate the stresses and strains throughout, once this is done the excess material which was left completely unstressed in the test, and therefore is not needed, can be highlighted and then cut away in the redesign. This can be done very quickly by a powerful computer whereas it may take a vast amount of time through physical testing or may not be achievable at all.

Performance of a part can be maximised via material selection. If this were to be done in a traditional way, without the use of FEA, it would endure a very long timeframe and increase manufacturing costs for each prototype to be made from a selection of different materials and to run each test, one by one to find the most efficient material. With the help of FEA programmes, the material can be selected and all of its physical properties will be used in a virtual test, this can be done for a selection of different materials and will output the results for comparison and the most efficient material can be selected in a much shorter time frame. The ability to calculate and see a visual of the part undergoing many physical parameters at once, such as temperature, stress and strain allows the designer to quickly make changes to a design to optimise its performance (PRE technologies, 2019).

These virtual FEA tests are carried out alongside physical testing as a means of improving and speeding up the design and testing process of parts, whilst still using the older physical testing methods, to verify results made by the computer programme and to ensure the product really can withstand the physical tests that it would pass in a computer programme. For example, a part could be designed and tested in CAD and pass all virtual load and stress tests, however when the physical test takes place, other factors could come into account and things like human error or flaws in a material could effect the results of a real life test.

Further advantages of using FEA alongside physical testing include the ability to safely simulate a potentially dangerous test on a part. For example, exerting a possible destructive load on a part to experiment its failure modes, this can easily be simulated in a computer programme and would show that the part would not cope under the given conditions. This same test would be far less safe to do physically as the people experimenting on the part could be unsafe.

Physical testing

Before FEA was an option for analysing products in the design process, engineers were bound to the use of hand written calculations and physical testing. Whilst there was no flaw in this method of testing and they did a satisfactory job at making sure designs met their performance requirements, they also limit the availability of performance statistics. This would often result in numerous prototypes, testing them and revising, making a new prototype every time. Hand written calculations also limit the amount of optimisation that can be done to a component in the design process due to complex designs being very difficult to analyse without a computer. FEA opens a gateway into much deeper, complex information about a products design performance.

Advantages to physical testing and hand calculations:

There is no need for the expensive software needed to undertake the FEA or the expensive, high powered computers required to run the software. This method can also provide a good starting point for a design and is typically a quicker process to set up than designing an FE model on a computer. Physical testing is also usually a satisfactory method of analysing a simpler design so sometimes FEA is not required.

When regarding the combination of the two methods, this can provide the added benefit of using the simpler method of analysing, to give a good starting point for the design. This can then be developed further later on in the design process using FEA to. Provide some more accurate and complex calculations. Hand calculations can also be used to validate an FEA model result, incase any error was made when inputting the values to the programme, it doesn't hurt to double check these values.

In some cases an FEA model can be produced of a part in a computer programme, all necessary forces, stresses and strains can be applied to see how the part will cope under these conditions. However, when attempting this same analysis as a physical test, it doesn't necessarily mean the part will act exactly the same under real life conditions. (Etcosten, 2019)

A method of having the added benefit of FEA without the expensive upfront cost is partnering with other engineering companies. Some manufacturing companies may decide they don't want to invest in FEA due to the high up front cost of licencing and training staff. Instead of paying this large initial investment, they can work together with another engineering company which specialises in finite element analysis, this can makes it cheaper for the manufacturing company, can provide a local specialist company with work and also could improve the quality of the work done in the FE analysis due to the engineers working on it being specialists in that specific field, rather than an engineer from the manufacturing company taking it on as a new skill.

Physical testing is a tried and tested, working method to analysing manufactured parts and assuring they are capable of withstanding the forces and stresses that they are designed for. Although these tests can be fully automated in a computerised system to simulate the conditions and optimise the part. That doesn't necessarily mean that FE analysis should ever completely take over physical testing. The combination of both methods creates an almost flaw proof system in which parts can initially be designed to a rough scale by hand. The design can then be taken into a finite element CAD programme where tests can make the part as strong, light weight and choose the most efficient material. This will limit the amount of physical prototypes needed to the very minimum value. These physical models can then be made, tested once more with the same conditions that the computer has simulated, to ensure that firstly, the computer was correct in its findings but also secondly, that there are no external issues that could cause a fault in the real world which are not taken into account in the FEA simulation.

A quote from (Cunningham, 2015)

"Endurance testing is costly and the real world always throws up more challenging conditions than the lab" shows a similar theory that just because a test has taken place in an FE analysis, a physical test can always be good for peace of mind that the same test can be passed in real world conditions.

Conclusion

To summarise this report, finite element analysis is a computerised simulation programme in which a part can be designed, made and tested under boundary conditions that can be set by the user. This analysis can be used to test things such as strength and optimise weight and efficiency of a part. This analysis can be carried out alongside physical testing, which is where a similar test is done on the physical part, to ensure it can withstand the loads and stresses necessary for when it is a working part. These two methods of testing prototypes combined can make the design process much more affordable and efficient than if physical testing were the only method adopted.

Physical testing and finite element analysis correspond as they are similar methods of testing, while one method is done to a real prototype of a part, using machinery to add forces and stresses in an attempt to push the prototype to its maximum load bearing capabilities. The other method of FE analysis is very similar, however the testing process is done through simulating the same tests on a computer by inputting all the same values for forces and stresses. However, computer programmes are able to simulate these tests within a very short time scale and allow the designer to make alterations to the virtual prototype within the CAD programme, in a matter of seconds. As opposed to having to make a complete new prototype every time a test shows a fault in the design.

YOU HAVE NOT DISCUSSED HOW FEA COULD BE USED AT A CONCEPTUAL STAGE & HOW THIS MAY IMPACT ON THE DESIGN PROCESS. HOWEVER, YOU HAVE DISCUSSED HOW IT CAN BE USED AS A VERIFICATION TOOL QUITE WELL.
MANY OF YOUR POINTS WOULD BE CLEARED WITH DIAGRAMS.

Bibliography

Cunningham, J., 2015. *physical vs virtual testing*. [Online]

Available at: <https://www.materialsforengineering.co.uk/engineering-materials-features/physical-vs-virtual-testing/86549/>

Element, 2020. *finite element analysis*. [Online]

Available at: <https://www.element.com/materials-testing-services/finite-element-analysis>

Etcosten, E., 2019. *FEA vs hand calculations*. [Online]

Available at: <https://asrengineering.com/2019/04/02/fea-vs-hand-calculations/>

PES performance, 2020. *finite element analysis*. [Online]

Available at: <https://www.pes-performance.com/analysis-simulation-testing-services/finite-element-analysis/>

PRE technologies, 2019. *advantages of finite element analysis*. [Online]

Available at: <http://www.pretechnologies.com/services/finite-element-analysis/advantages>

YOU HAVE NOT PRESENTED
A CASE STUDY