

Applied Mathematics Mathematical Modelling Report Writing Booklet





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Writing A Report - Applied Mathematics Modelling Project

Applied Mathematics students must complete a modelling project and report in response to a brief issued by the State Examinations Commission (SEC) in 6th year.

Your report must not exceed 900 words (excluding references, equations, diagrams, graphs, etc.). Your report must not include more than 20 images. An image can be any relevant table, graph, chart, diagram or photograph. The total file size of your digital report including all embedded images must not exceed 100 MB. Videos must not be included in your report.



Understand the brief!
The most important step is to unpack the brief you have been given and understand exactly what the purpose of your project will be.

The SEC have published an [Information Note](#) reviewing the coursework components of recent subjects that have new specifications. It offers an insight into good practice observed by examiners of student work as well as advice on engaging with the coursework. Below are some key examples of these.

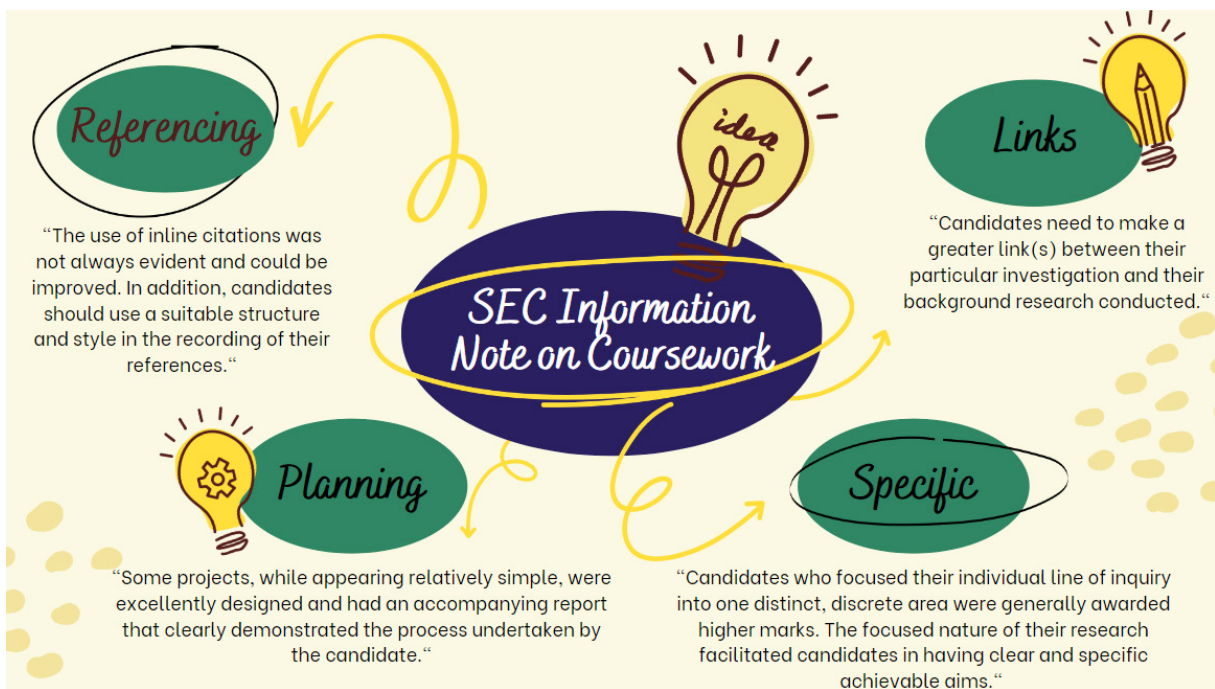
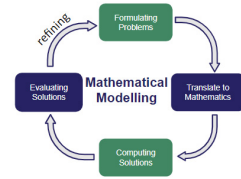


Figure 1: Information note for four Leaving Certificate subjects with new subject specifications (SEC, 2021)

There will be three sections to this document:

1. Research and Referencing Skills
2. Comprehension Strategies and Presentation of Ideas
3. Interpreting and Representing Data



1. Research and Referencing Skills



Researching for your project

When engaging with research to find out more about a certain area of interest, it is important to be aware of what are reputable sources and what are not. While the use of search engines and YouTube may be an obvious place to start, you must be careful of whether the information is reliable and suitable for your project.

Determining the credibility of a source:

- There is a vast amount of information available online so it is important to be able to judge what content is accurate and reliable and what is not. Not all information available online is correct or from a reliable source (Chat forums or Wikipedia may not be reviewed for credibility).
- Information that is peer reviewed (checked by others for accuracy) has high reliability as it has been approved by experienced people in that area.
- Check other sources: Can you find the same information on other reputable websites? Do they provide their sources? If similar information can be found from different independent sources then there is a better chance that it is reliable.
- False information often contains incorrect dates or altered timelines. It is also a good idea to check when the article was published, is it current or old? Check when an article was written or last updated. If you can't tell when a source was written, then keep looking until you find a good source about the topic that does have a recent date, so you can see if anything has changed.
- Are your own views or beliefs affecting your judgement of how accurate or reliable a piece of information is? In general, we are all drawn to information that confirms our own beliefs or biases. Online algorithms that are designed to give us news and information based on our personalised searches and interests make it harder to see beyond our own world view.



Remember to constantly refer to your problem statement and ask yourself, if and how the information fits into your project.

Researching online:

- When looking at online search results, don't just use the first result in the list. This can be sponsored or optimised for other reasons resulting in them not being the best quality for your search.
- When you find some interesting information, it can be helpful to bookmark it so that it is easily accessed at a later date.

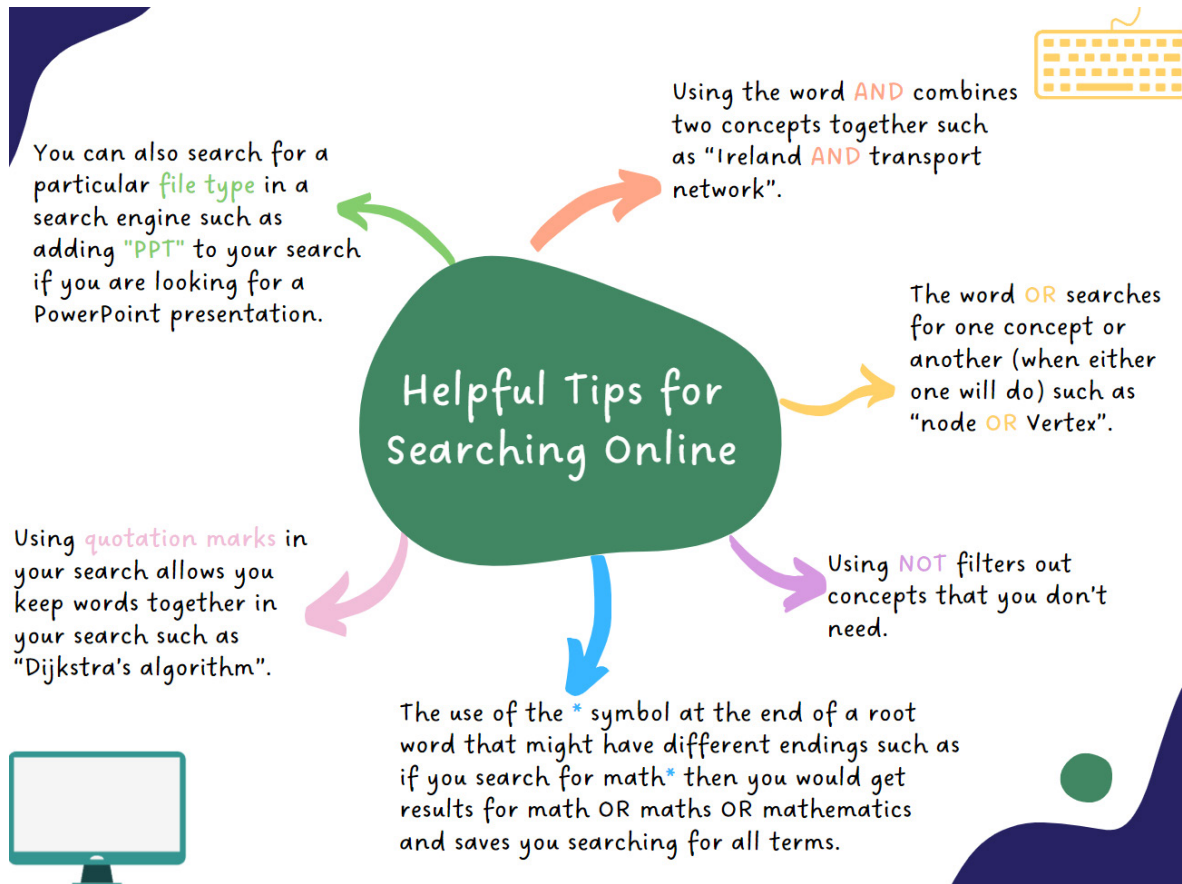
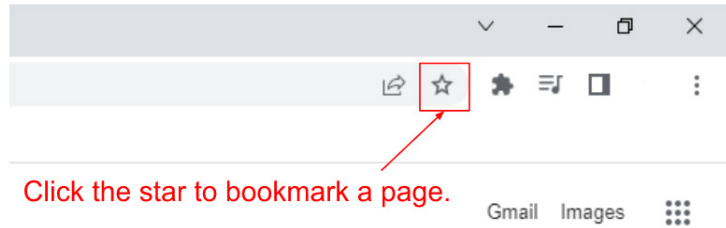


Figure 2: Helpful Tips for Searching Online

Online Research: Tips for Students: <https://youtu.be/LTJygQwYV84>

Helpful Resources:

- [Webwise Connected](#) (Information regarding Online Wellbeing; News, Information and Problems of False Information; Big Data and the Data Economy; and My Rights Online).
- [Internet Safety and Information Videos](#) (Videos about Big Data, False Information, Safety and the connectedness of the internet).
- [Snopes](#) (Website about fact checking and misinformation).
- [All about Explorers](#) (Website about searching better on the internet).
- [Internet Literacy Handbook](#) (Council of Europe, 2017)

Referencing:

Any information used in your report that you gathered from a secondary source must be referenced whether it be direct quotations adapting someone else's ideas/work in your writing. There is no problem using information that isn't your own but you must acknowledge the source and also allow readers to find the material that you have mentioned. Information could come from various sources such as books, professional journals, government reports, online sources or relevant individuals.

Referencing the work of other people involves two distinct elements:

- An in-text citation
- A reference list

In-text citations are inserted in the main body of your text and indicate that you are using or directly quoting someone else's work. It usually just involves the author's name and date that the work was published with full reference details found in your reference list.

When giving further details in the reference list you may need to include a selection of the following details:

- Author
- Year of publication
- Title of article or chapter
- Title of the publication
- Issue and volume numbers
- Place of publication
- Publisher
- Edition
- Page numbers
- URL
- Date you accessed the material

Example of Referencing a Website:

In-text Citation: Ireland's population rose by 7.6% since 2016 (Central Statistics Office, 2022)

Your Reference List: Central Statistics Office. 2022. Central Statistics Office website. [online] Available at: <https://www.cso.ie/en/releasesandpublications/ep/p-cpr/censusofpopulation2022-preliminaryresults/> [Accessed 26 September 2022].



2. Comprehension Strategies



As you research and gather information relevant to the specific problem that you are modelling it is important to synthesise all of the information that you have gathered into effective paragraphs. Don't just start writing as soon as you begin researching for your project, think about the overall report and plan its structure. Consider how you will communicate your work as effectively as possible and ensure that there is a logical flow to your writing. While writing, consider using transitions which connect the last sentences/ideas you wrote and what you're going to say next.

Creating an initial outline of the report may be helpful to organise your research and writing as well as give you a guide to follow as you write. When writing about the research that you have conducted for your project it is not simply 'copying and pasting' but using your research to show an understanding of the information and how it is applicable to and enhances your project. Your background research should be relevant to your specific model and strong links should be made between research and the problem that you are modelling.

Introduction and Research

The purpose of the introduction is to identify the specific problem(s) to be modelled and engage with background research on the brief as well as research the specific problem. It is important to understand the purpose of your research and if certain research is more relevant to your specific modelling problem than others. As you engage with research and gather/present relevant data you should identify relevant variables for the particular problem that you will be modelling.

It is important to use your word count effectively so ensure that each of the following items are engaged with appropriately:

- Background research on brief
- Identify specific problem(s) to be modelled
- Research specific problem(s)
- Identify relevant variables
- Present relevant data
- Provide citations and references

Sentence Stems:

Sentence stems can be useful when writing as they avoid the overuse of certain phrases and can help communicate your work better. Below are some possible sentence stems that may be helpful for different aspects of your report.

Introduction

The aim / intention / purpose of this report is to outline / present / discuss / sum up ...

I have recently visited ... and have prepared the following report for your consideration.

This involved visiting / looking at / investigating ... / The data was obtained by ...

In order to help make this report I asked / discussed / gave out a questionnaire ...

It is based on my observations / the feedback from participants ...

My findings are outlined / presented below. / I outline my findings below.
The report contains the relevant details concerning the problem as you required.

Introducing Points

To begin with ... / Let us start with ...
First(ly) ... / In the first place ... / First of all ... / The first aspect / thing to consider is ...
Second(ly) ... / Third(ly) ...
Moreover ... / Furthermore ... / What is more ...
Another aspect to consider ... / Yet another aspect / consideration is ...
Besides that ... / Apart from that ... / In addition to this ... / On top of that ...

Introducing Your Opinion

I think / believe that ... / In my opinion ... / I am of the opinion that ... / It seems to me that ...
Personally I believe that ... / In my view ... / If you ask me ... / To my mind ... / As far as I am concerned ...
I would like to suggest / recommend ... / I therefore suggest / recommend ...
I (strongly) recommend ... / My recommendation is to ...

Introducing Someone Else' Opinion

A few / Many / The majority / minority of people said / reported / complained ...
According to ... / As ... said ... / In the words of ...
It is said that ... / It is often suggested that ...

To Cite an Idea

According to...
As explained by...
As seen by...
Based on the ideas of...
...showed that...
...explored the idea...
...wrote that...
...disputed/claimed/suggested that...
Similarly, ...stated that...

Giving Examples

For example / instance ...
This can be shown / illustrated / demonstrated / clarified by ...
The picture / diagram shows / illustrates ...

Comparing

One of the main / biggest / most significant / ... differences between ... and ... is ...
Unlike ..., ... is ... / While / Whereas / Although ... is, ... is ...
... is completely / entirely / totally different from ...
... is a little / slightly / somewhat / a great deal bigger / more elegant / ... than ...
... is not quite / nearly as comfortable / expensive / convenient / ... as ...
... is virtually / exactly the same as ... when it comes to ...

To Evaluate

Based on... I determined that...

My judgement of...was...because...

I evaluated...on the following criteria... I assessed that...

My interpretation of...was...

When ranking its importance...I felt that...because...

When I compared..., I discovered that...

To Analyse

The fact that...shows that...because...

Based on..., I can conclude...because...

All of this goes to show that...because...

This is significant because...

My interpretation of...was...

After careful examination of...it appeared that...

Taken together, the fact that... It...clearly demonstrated that...because...

Conclusion and Recommendations

When writing a conclusion, it is important to make connections with other parts of your project such as background research, relevant data, assumptions, iterations and results.

The purpose of conclusions and reflections is to **interpret the meaning of the solutions to your model in a real-world context**. It allows you to summarise all of the work that you have done and make statements based on your findings and **reflect on the outcomes of your model and the process itself**. A conclusion also provides you with an opportunity to make recommendations for the particular context that you are modelling based on your findings as well as recommendations for future research that is needed.

Sentence stems for writing a conclusion:

It can be seen from the data / reactions / information above that ...

All things considered, I believe that ... / Taking everyone's comments into consideration ...

In general / On the whole I found that ...

In conclusion ... / To conclude ... / To sum up ... / In summary ...

3. Interpreting and Representing Data



It is important when working with data to have an understanding of the various types of data, what they mean and how best to represent data. **Primary data** is data that is gathered by the person who is going to use the data while **secondary data** refers to data that has already been collected by someone else previously.

When working with data, both qualitative (categorical) data and quantitative (numerical) data can be used. Long lists of data can be difficult to interpret so suitable graphical representations can be helpful to summarise the data and understand its meaning. Data representations can be useful in determining the trend in data over time, if there is a relationship between two variables or how much data falls in a specific category or range of values.



It is not enough to just present data/information, you should analyse it and draw conclusions from it. Relate the information to your problem statement and model.

Gathering and Representing Data

Not all of your modelling/results needs to be represented using just mathematical calculations; the use of graphs, tables or other suitable representational forms may be more suitable depending on the results or the message that you are trying to convey. Overusing one format of representing data should be avoided. Choose the format that best suits the data and what you are trying to highlight. Where appropriate, you should use titles, legends for the presentation of data and information. **Images should be labelled properly (Figure 1, Figure 2, etc.) as well referred to by their figure name in body of the report. Tables can be referred to as Table 1, Table 2, etc.** Also, if images/graphs are from a secondary source then they must be referenced.

If you are presenting calculations in your report then make sure that they are easy to read and assigned the correct unit (if applicable). Discuss what your calculations mean in the context of what you're modelling and how your model is progressing compared to previous iterations.

Choosing the Most Suitable Method of Representing your Data

There are many ways of representing data and while a certain method may look good it may not be the most appropriate for what you are trying to show. It's important that whoever is reading your project is able to understand it and any method of representing data is easy to follow.

When choosing your visual representation, think about its purpose and what message you want to communicate. Is it to show the relationship between different variables or is it to compare certain items over a certain period of time? Figure 3 below may be helpful in determining the most suitable data representation type.

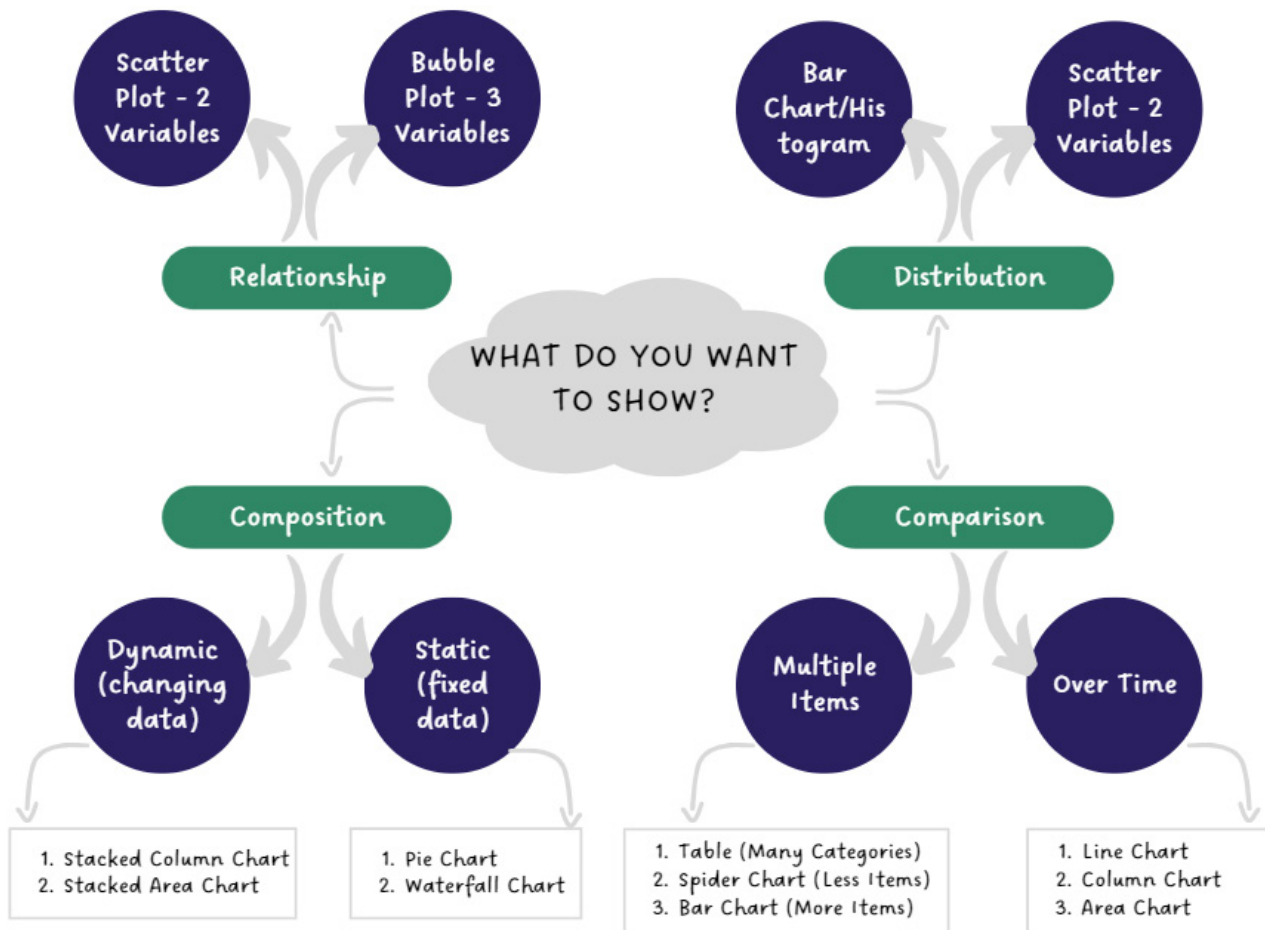


Figure 3: Choosing the Right Data Representation Type

Every project/report is different resulting in different data representation types suiting varying goals, aims or topics. If you are looking to communicate a particular trend over a certain period of time then a line chart, column chart or area chart could be the most suitable. If you are comparing two or more sets of information then the choices could be a bubble chart, spider graph or scatter plot.

To summarise, here are a number of data representation types and their uses that may be helpful:

1. Number Chart - gives an instant overview of a specific value.
2. Line Chart - demonstrates trends and changes in data over a period of time.
3. Maps - visualises data by geographical location.
4. Waterfall Chart - demonstrates the static composition of data.
5. Bar Graphs / Histograms - used to compare data of many items.
6. Pie Chart - expresses a part-to-whole relationship in your data.
7. Gauge Chart - used to display a single value within a quantitative context.
8. Scatter Plot - applied to express relations and distribution of large sets of data.
9. Spider Chart - comparative charts great for rankings, reviews, and appraisals.
10. Tables - shows a large number of precise dimensions and measures.
11. Area Chart - portrays a part-to-whole relationship over time.
12. Bubble Plots - visualises 2 or more variables with multiple dimensions.

General Rules for Representing Data:

1. Keep it simple. Huge amounts of data and graphs can result in readers becoming lost and struggle to see the key information.
2. Begin general and then move to more specific. Start with the bigger picture and wider information and then focus on key findings and relevant analyses.
3. Data should be related to and answer the goal of the modelling project (the problem statement).
4. Always use the past tense when describing results.
5. Do not repeat the same information in more than one format. Select the best method and communicate the information.
6. Whether the graph was created by you or a secondary source, you should reference it in your report to demonstrate its relevance for your project and its impact on your mathematical model.

Useful Links:

Guidance to Support the Completion of the Modelling Project:

<https://curriculumonline.ie/getmedia/8f2d896c-d95f-47a6-b41a-af045cffc851/21042-Leaving-Cert-Applied-Maths-Guidance-for-Modelling-v3.pdf>

[Applied Mathematics Sample Mathematical Modelling Brief:](https://www.examinations.ie/misc-doc/IR-EX-58601707.pdf)

<https://www.examinations.ie/misc-doc/IR-EX-58601707.pdf>

Applied Mathematics Mathematical Modelling Reporting Booklet:

<https://www.examinations.ie/misc-doc/IR-EX-6594143.docx>

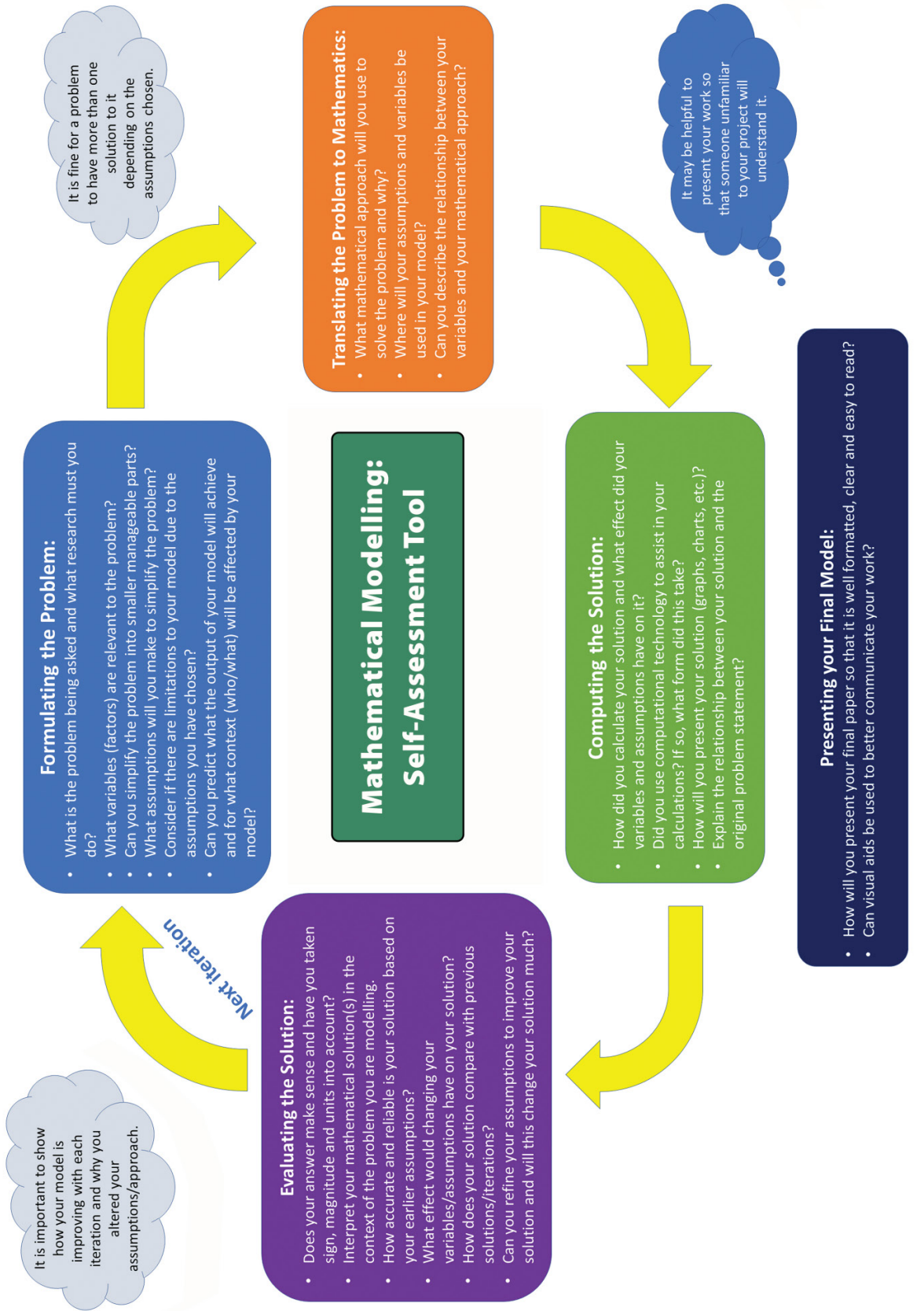
Note: Both links to SEC material can be found in: "Examination Information" > Project and "Practical Coursework".

Appendix:

Report Structure and Mark Allocations

<i>Section</i>	Indicative Content	Marks
<i>Introduction and Research</i>	<ul style="list-style-type: none"> • Background research on brief • Identify specific problem(s) to be modelled • Research specific problem(s) • Identify relevant variables • Present relevant data • Provide citations and references 	20
<i>The Modelling Process</i>	<ul style="list-style-type: none"> • Explain and justify model and assumptions • Compute solutions • Present solutions using appropriate mathematical and graphical representations • Analysis of solution(s) – sensitivity to changes in assumptions; comparison with other solutions or real-world data • Iterative process 	50
<i>Interpretation of Results</i>	<ul style="list-style-type: none"> • Interpretation of solution(s) in real-world context • Conclusions and reflections 	15
<i>Communication and Innovation</i>	<p>This is not a distinct section of the report.</p> <ul style="list-style-type: none"> • Innovative and creative approaches • Overall coherence 	15

Source: State Examinations Commission Sample Brief, March 2022



THE STUDENT DEMONSTRATING A HIGH LEVEL OF ACHIEVEMENT:	THE STUDENT DEMONSTRATING A MODERATE LEVEL OF ACHIEVEMENT:	THE STUDENT DEMONSTRATING A LOW LEVEL OF ACHIEVEMENT:
<p>states the problem statement concisely, early in the written report. References sources from background research.</p> <p>identifies several variables affecting the model and notes and justifies the need for the main factor that influences the phenomena being modelled.</p> <p>clearly identifies and justifies the assumptions used to develop the model and, where appropriate, states the limitations of the simplification of the problem due to the assumptions made.</p> <p>indicates exactly what the output of the model will be and, if appropriate, identifies the audience and/or perspective of the modeller.</p>	<p>identifies a problem statement which is not precise or consistent with other statements in the report.</p> <p>lists important parameters and variables properly, but without sufficient explanation.</p> <p>notes primary assumptions, but without justification.</p>	<p>presents a problem statement that is difficult to understand or is buried in the text.</p> <p>identifies assumptions and justifies them, but they are difficult to identify in the text.</p> <p>barely mentions variables/ parameters or, if mentioned, they are difficult for the reader to identify in the text.</p>
<p>provides clear insight with logical mathematical reasoning into the mathematical method(s) used to describe the relationship between the variables, and to solve the problem. Presents a plausible approach and outcome.</p>	<p>states a mathematical approach, however with aspects of the method(s) which are inconsistent, difficult to understand or incomplete.</p>	<p>states a model which contains fixable mathematical errors.</p>
<p>clearly presents an accurately computed solution and analysis of the relationship between variables, supported where appropriate with visual aids and graphic representation that is consistent with the original problem statement.</p>	<p>states an answer, however with aspects of the solution(s) which are inconsistent, difficult to understand or incomplete (e.g. fails to identify units of measure).</p>	<p>states an answer but without contextual background (i.e. appropriate graphics, appropriate units, etc.).</p> <p>arrives at no solution.</p>
<p>addresses the viability and reliability of the mathematical modelling solution.</p> <p>considers how sensitive the model is to changes in parameter values or altered assumptions; how it compares to other solutions or historical data. The model is refined and the process iterated.</p>	<p>addresses the viability and reliability of the mathematical modelling solution, however with analysis which lacks proper dimensionality, e.g. obvious consequences of the stated outcome are ignored or well-known comparisons are disregarded.</p>	<p>provides some analysis but without any sense of perspective.</p> <p>uses incorrect mathematics in the analysis.</p>
<p>presents a paper that is well-formatted and enjoyable to read, with easy to interpret visual aids (if appropriate).</p>	<p>presents a paper with multiple spelling, formatting or grammatical errors, visual aids which are missing key readability features or which do not clearly connect to the solution.</p>	<p>presents a paper with significant disregard for common spelling, grammatical and mathematical rules.</p>

Source: Leaving Certificate Applied Mathematics Specification



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