MST210

TMA 07

Contents **Cut-off date**

2 TMA MST210 07 (modelling activity assignment) 29 April 2015

The module website gives details of how to submit assignments for this module.

In order to encourage you to present your report in a good mathematical style, your tutor will comment on how you:

- use correct mathematical notation
- define any symbols that you introduce in formulating and solving a problem
- give references for standard formulas and derivations
- include comments and explanations within your mathematics
- explicitly state results and conclusions, giving answers to an appropriate degree of accuracy and interpreting answers in the context of the question
- draw diagrams and graphs.

These features are seen as being essential to complementing your mathematical skills. Your tutor will make comments on how well you achieve these objectives and give you guidance on how to satisfy them.

Five of the marks for this TMA will be allocated to the way you write your report. It is expected that most students will receive the majority of these presentation marks; such marks are included in TMAs to encourage, and emphasise the need for, thinking about how you present your mathematics.

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This assignment covers mathematical modelling.

Question 1 – 10 marks

Briefly describe in approximately 100 words (maximum 200 words) how your modelling group worked together and your role within the group. The marks awarded for this question relate to the group activity.

Question 2 – 85 marks

You should extend and complete your modelling work on one of the two problems listed on page 4, and write up your work in the form of a report.

The mark scheme for this report is given on page 5. This mark scheme shows section headings for the report together with suggested contents for each section. The first four sections of the report should normally be based on the first model that you derived as part of the group activity, but you are under no obligation to use the first model that the group derived. You should complete the modelling assignment yourself by evaluating your first model and suggesting a revision of the model. The revised model should lead to a change of the model equations, rather than merely changing the value of a parameter of the first model.

As a rough guide, a report of 2500 words would be sufficient to gain full marks. Experience indicates that a report of less than 1500 words is unlikely to address adequately all of the issues. In no circumstances should your report exceed 3500 words; you may be penalised by up to 10 marks if it does. If a report obviously exceeds that limit, then your tutor will not mark any material beyond 3500 words. (These word limits may be taken as excluding the captions for diagrams or graphs, and the linking words between equations.) You may include appendices to your report to give additional information. These appendices do not count towards the word limit, nor will they be assessed by your tutor.

Your purpose in writing this report is to explain to your tutor what results you obtained and how you obtained them, and to do this clearly and fully, so that he or she will be left in no doubt about what you have achieved. After all, your tutor cannot award marks for work that he or she does not understand, nor can your tutor be expected to guess what you did if you have not written it down. It is your responsibility to explain your work satisfactorily.

You may use Maxima (or other computer software) in your work, but you must clearly show both the input and the output.

Writing guidance

Your report will actually be read (and marked) by your tutor, of course; but in writing your report, you may find it helpful to imagine that it is to be read by another student. This should allow you to make sensible judgements about the amount of mathematical detail to include.

You do not need to aspire to exacting standards of literary style. Your tutor will not worry unduly about occasional spelling mistakes. On the other hand, you should be concerned with those aspects of writing that are closest to mathematics: being systematic; laying out your work in a logical fashion; making sure that each step of an argument or calculation follows from the previous one; avoiding any obscurity or ambiguity in the use of symbols and technical terms; using appropriate diagrams and tables. Moreover, no piece of writing is going to make much sense if it contains lots of meaningless or ambiguous sentences, so you should also ensure that what you write is clearly expressed.

Your report does not have to be *drafted* in the order in which it will be finally presented and read. Most people find it quite difficult to write anything longer than a postcard by starting at the beginning and keeping steadily on until the end is reached. It is usually necessary to make at least one rough draft, and to work backwards and forwards through the draft as the ideas develop. If you proceed in this way, you will find that the resulting account of your model is more comprehensive and better structured than if you just start at the beginning and carry on to the end.

Take every opportunity to include figures and illustrations in your report. You can give sketches of graphs, drawings of experimental equipment, and diagrams of processes and relationships. You can also include output from Maxima. Explanations of complicated derivations are often easier to understand if they are accompanied by appropriate diagrams. Data, numerical results and even lists of variables are usually best displayed in tables.

You may find it helpful during your later work on this report to find one or two (non-mathematical) friends who might be interested in the problem that you are going to solve. Persuade them to be your *audience*, and ask them to read your report when first drafted. Your audience will be useful for discussion when you become stuck, and should help you to produce a report that is clear and easy to understand.

Try to be concise when stating the assumptions of your model. The list of assumptions should be necessary and sufficient to derive your model. When creating your model, you should refer back to each assumption as it is used in the derivation. When you have done this, if there is an assumption that you have not used, then consider carefully whether the assumption is not necessary or whether some step in your derivation uses the assumption but has not been explicitly referenced.

In the 'Do the mathematics' section of the report, any graphs displayed should be for typical values of the parameters as they are intended to show general behaviour of the first model. Data related to a specific problem are part of the interpretation of the results and belong in the next section.

When evaluating the model, you should review every assumption.

The conclusion of the report should be just a summary of what you have done, and should not contain any new derivations or results.

Modelling problems

You should choose one of the following problems to address in the modelling activity.

Problem 1: Preventing injury caused by falling objects

When work is being carried out on a sloping roof, it is possible for objects such as broken slates, hammers and other tools to slip down the roof and cause injury to passers-by. For taller buildings, where scaffolding is used, adequate precautions to stop these objects falling onto the ground are in place. However, for minor works, and particularly those attempted by house owners themselves, such precautions are not normally considered. It is possible that the builder or house owner might lose an action for negligence in the event of an accident of this kind, if no steps had been taken to prevent it.

The proposal for preventing accidents is this: whenever work is being done on the roof of a building, and there is no scaffolding or other structure to stop falling objects, a strip of the pavement or other ground immediately adjacent to the wall of the building below the relevant roof should be cordoned off to prevent any objects that fall off the roof from landing on a passer-by. Use your mathematical modelling skills to estimate the width of pavement or other ground that should be cordoned off.

Problem 2: Ramps in terminals

In transport terminals such as airports, there is often more than one level. Passengers have baggage that is usually moved from place to place using baggage trolleys; a way to move from one level to another is via a ramp. The slope of the ramp is important: if it is too steep, then the passengers will not be able to push the trolleys up the slope, nor will the brakes stop a trolley from careering down the slope if it is left unattended; if the slope is too shallow, then the passengers have to walk a long way and the ramp requires more building materials. Use your mathematical modelling skills to suggest the optimum slope of such a ramp.

(There is a British Standard recommendation for the slope of ramps in public buildings – and other countries may well have similar standards. However, it is not clear whether the value for this standard slope was derived by a mathematical model or whether it was a value that ‘seemed right’. One of the roles of the mathematical modeller is to examine such pronouncements critically and to consider whether an improvement can be made.)

Mark scheme

The mark scheme is based on the following structure for the report, to which you are strongly recommended to adhere as it will make it easier for your tutor, or any other reader, to follow your ideas and work. How you write your report will depend to some extent on the problem that you have chosen and the model that you have developed, but the points itemised below under each section heading should be addressed in your report.

1 Specify the purpose of the model **5 marks**

- define the specific problem to be solved
- describe the features of the problem that you are going to investigate.

2 Create the model **30 marks**

- give a qualitative outline of the mathematics to be used in the model
- state assumptions
- choose variables and parameters
- formulate mathematical relationships.

3 Do the mathematics **10 marks**

- solve your mathematical relationships
- draw graphs showing typical relationships
- derive a first model
- use dimensional analysis to check your model.

4 Interpret the results **10 marks**

- collect relevant data for parameter values
- describe the mathematical solution in words
- evaluate the sensitivity of the model predictions to changes in the values of parameters
- decide what results to compare with reality.

5 Evaluate the model **15 marks**

- collect data to compare with the model
- test the model by comparing clearly presented predictions of your first model with reality
- criticise the model using the results of your tests
- review the assumptions.

6 Revise the model **10 marks**

- explain why the revision is justified, based on your criticism of the first model
- give a description of the intended revision
- formulate a revision of your first model.

(*Do not attempt to solve the revised model.*)

7 Conclusions **5 marks**

- summarise the performance of your first model and any attempts to improve on it, plus any thoughts about the modelling process.