

# INSTITUTE AND FACULTY OF ACTUARIES

## EXAMINATION BOOKLET

May 2015

### CA2: Model Documentation, Analysis and Reporting

### Paper 1

**DO NOT OPEN UNTIL INSTRUCTED TO DO SO.**

#### Examination instructions

1. You should periodically save all the files you are working on onto the PC's hard drive.  
You will be given instructions for submitting your work at the end of the examination.  
**It is your responsibility to ensure your work is adequately saved.**
2. At the end of the allotted time, or when you have completed your exam, you need to submit your work.  
Your filenames must include your ARN (e.g. **Audit\_ARN.docx**). Ensure that your spreadsheet model and audit trail are clearly labelled and also contain your ARN as a header or footer on at least one page.  
**Please note that you should use your ARN and NOT your name on all of the material you submit for marking.**  
**The work you submit MUST be saved in Microsoft 2007 format, i.e. using docx (Word) or.xlsx (Excel) file extensions. Do not embed documents in your spreadsheet.**
3. You must submit your spreadsheet model and audit trail by the end of the stated exam time. By submitting your files you are confirming that all material is entirely your own work and you wish this to be taken into account for this assessment.  
**It is your responsibility to ensure that a complete electronic copy of your work is submitted.**  
You must stop working after this time as failure to do so could result in your exam not being marked.
4. You must also hand in this examination booklet, together with any other materials from the examination. This includes handing in any planning or rough notes that you have made during the examination, and any print-outs that you have done of your work.

**Professional behaviour is mandatory and no material relating to the exam may be taken from the exam room nor disclosed or discussed with others.**

**Failure to comply with this will be deemed to be a breach of examination regulations and may result in disciplinary action.**

**This booklet contains an insert with additional guidance.**

**Data has been provided electronically.**

**You should use the first 15 minutes of the exam as reading and planning time.**

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## Exam requirements

1. Read the background document, which describes the scenarios that need to be modelled and documented for this project. Technical assistance for the modelling work, should you require it, can be found in the additional guidance contained in this booklet.

*No marks will be deducted for the use of this guidance.*

2. Construct a spreadsheet model that produces the following calculations and charts. You should ensure that your spreadsheet contains appropriate self-checks and that you have performed robust reasonableness checks at each stage of your calculations.
  - (i) Validate the competitor data supplied for the charity triathlon and amend any corrupt or missing data. [8]
  - (ii) Calculate each competitor's speed for each stage of the charity triathlon. [2]
  - (iii) Calculate each competitor's expected speed for each stage of the Minister's triathlon, using your results in part (ii) and the formula and parameters provided. [2]
  - (iv) Calculate the expected time for each competitor to complete each stage of the Minister's triathlon, and hence each competitor's overall time for the triathlon. [2]
  - (v) Determine the position in which each competitor is expected to finish in the Minister's triathlon. [2]
  - (vi) Calculate summary statistics (min, max, mean and interquartile range) for the competitors' expected overall times for the Minister's triathlon. [2]
  - (vii) Illustrate the summary statistics from part (vi) using a single chart. [3]
  - (viii) Calculate the prize money paid out for the Minister's triathlon. [2]
  - (ix) Calculate the total income and outgo for the Minister's triathlon and hence determine the overall profit or loss. [2]
  - (x) Illustrate the total income, outgo and profit or loss from part (ix) using a single chart. [2]
  - (xi) Repeat the calculations in parts (iii), (iv), (v), (viii) and (ix) in order to determine a new  $\lambda$  parameter for the swim stage such that the event makes a zero (or close to zero) profit. [3]
  - (xii) Calculate the percentage change in swim times needed for the event to make a zero (or close to zero) profit. [1]

### Marks available for spreadsheet model and checks:

|  |      |
|--|------|
| Accurate completion of above modelling steps and data checks | [31] |
| Demonstration of good modelling technique and practice       | [7]  |
| Other (non-data) checks                                      | [7]  |

[Sub-total 45]

**3. Produce an audit trail for your spreadsheet model which includes the following aspects:**

- purpose of the model
- data and assumptions used
- methodology, i.e. description of how each calculation stage in the model has been produced
- explanation of the checks performed

You should ensure that your audit trail is suitable for both a senior actuary, who has been asked to approve your work, and a fellow student, who has been asked to peer review and correct your model, or to continue work on it, or to use it again for a similar purpose in the future.

**Marks available for audit trail:**

**Audit approach**

- **Fellow student can review and check methods used in the model** [8]
- **Senior actuary can scrutinise and understand what has been done** [8]
- **Written in clear English** [4]
- **Written in a logical order** [3]

**Audit content**

- **All steps clearly explained** [7]
- **Clear signposting included throughout** [5]
- **Statement of assumptions made** [5]
- **All model steps accurately covered** [15]

**[Sub-total 55]**

**[Total 100]**

## Background

The Minister for Sports on the Island of IFoA hosts an annual Minister's triathlon event each September. This is a triathlon over three stages, each covering a different sporting discipline as follows: a 3km swim, a 30km bicycle ride and a 6km run.

To be able to compete in the Minister's triathlon competitors must be registered by the end of June. Each year a maximum of 30 competitors can register for the event.

Earlier this year a charity triathlon was held. It is understood that the competitors have treated the charity triathlon as a practice event for the Minister's triathlon.

### Charity triathlon

The charity triathlon consisted of:

- a 750m swim.
- a 20km bicycle ride.
- a 5km run.
- two transitions, the first (T1) between the swim and bicycle stages (where the competitor takes off his wet suit and mounts his bicycle), and the second (T2) between the bicycle and run stages (where the competitor dismounts his bicycle and stores it on the rack).

The Minister for Sports has provided the results of the charity triathlon for the 30 competitors who are registered for the Minister's triathlon. These results are in an Excel spreadsheet and a copy is included in this booklet.

### Minister's triathlon

You are an actuarial student working for a consultancy on the Island of IFoA. The Minister for Sports has approached your boss, a senior actuary, and asked her to help with predicting the results of the Minister's triathlon, and the expected spread of results for the event.

Your boss has suggested you use the following relationship between the speeds in future triathlons compared to the speeds in the charity triathlon:

$$\text{Speed in future triathlon} = \text{Speed in charity triathlon} \times \left[ \frac{1}{1 + 2e^{\lambda d}} + \frac{2}{3} \right]$$

where:

- $\lambda$  is a constant which is specified for each discipline:

for the swim,  $\lambda = 3$ ;  
for the bicycle ride,  $\lambda = 0.07$ ;  
for the run,  $\lambda = 0.025$ .

- $d$  is the number of extra km distance in the future triathlon compared to the charity triathlon.

## **Profitability**

The Treasurer has raised concerns about the cost of running this event.

Each competitor pays a fixed fee of \$50 to register for the Minister's triathlon.

However, in order to encourage a high level of competition, a discount of 25% of the fee is offered to anyone who finished in the top 10 of the charity triathlon.

In recent years, for each Minister's triathlon, fixed expenses of \$150 and a per competitor expense of \$2 have been incurred.

The Minister's triathlon also awards a prize to the top three competitors. The amount of prize money depends on the finishing position and the number of minutes the competitor's total time falls under 3 hours, as follows:

$$\text{Prize Money} = \text{Multiplier} \times \text{Minutes under 3 hours}$$

where the multiplier is:

- \$20 for the first placed competitor.
- \$7 for the second placed competitor.
- \$3 for the third placed competitor.

Your boss has asked you to estimate the income and outgo and determine the overall profit or loss to the Island of IFoA, using the above information.

## **Break even point**

The Minister for Sports would also like to know what percentage change across all swim times (i.e. the same percentage change for every competitor) would be needed in order for the Minister's event to break even (i.e. make a zero profit, or as close to zero as is possible).

In order to determine this percentage change, your boss has asked you first to determine a new constant  $\lambda$  for the swim discipline which is needed to generate a zero (or close to zero) profit.

You will then be able to calculate the percentage change in swim times using this new swim constant  $\lambda$  relative to your boss's initial suggestion for the parameter value of  $\lambda = 3$ .

Unfortunately, your boss is out of the office visiting a client and cannot be contacted for the rest of the day. She would like the above calculations finished and the required charts produced, along with an audit trail, on her return.

# Data

## Results of charity triathlon

Source: Minister for Sports

| First Name | Last Name | Finish time | Swim Stage Time | T1 Time  | Cycle Stage Time | T2 Time  | Run Stage Time |
|------------|-----------|-------------|-----------------|----------|------------------|----------|----------------|
| Steve      | Greene    | 01:06:52    | 00:10:41        | 00:01:23 | 00:32:42         | 00:00:53 | 00:21:13       |
| Alan       | Clark     | 01:06:54    | 00:10:36        | 00:01:06 | 00:33:28         | 00:00:57 | 00:20:47       |
| Nick       | Cridlan   | 01:08:41    | 00:10:58        | 00:01:25 | 00:34:49         | 00:00:48 | 00:20:41       |
| Chris      | Maunder   | 01:09:02    | 00:08:51        | 00:01:34 | 00:36:51         | 00:01:14 | 00:20:32       |
| Conal      | Newland   | 01:09:42    | 00:10:08        | 00:01:31 | 00:35:59         | 00:01:19 | 00:20:45       |
| Richard    | Wilks     | 01:09:49    | 00:11:04        | 00:01:21 | 00:35:18         | 00:00:55 | 00:21:11       |
| Tom        | Newman    | 01:10:38    | 00:12:02        | 00:01:17 | 00:35:13         | 00:01:04 | 00:21:02       |
| Jason      | Baggaley  | 01:10:46    | 00:10:47        | 00:00:00 | 00:35:43         | 00:00:57 | 00:21:46       |
| James      | Goymour   | 01:10:53    | 00:12:55        | 00:01:12 | 00:36:09         | 00:00:44 | 00:19:53       |
| Henry      | Franklin  | 01:11:13    | 00:11:39        | 00:03:06 | 00:31:14         | 00:02:03 | 00:23:11       |
| Martin     | Pitts     | 01:11:33    | 00:10:45        | 00:01:32 | 00:35:40         | 00:01:00 | 00:22:36       |
| Chris      | Rees      | 01:12:00    | 00:12:49        | 00:01:21 | 00:35:21         | 00:01:00 | 00:21:29       |
| Melissa    | Brand     | 01:12:03    | 00:11:36        | 00:01:05 | 00:35:30         | 00:01:02 | 00:22:50       |
| Richard    | Bashford  | 00:52:13    | 00:12:23        | 00:02:01 | 00:36:51         | 00:00:58 | 00:00:00       |
| Neil       | Kerfoot   | 01:12:21    | 00:10:58        | 00:01:11 | 00:36:36         | 00:01:07 | 00:22:29       |
| John       | Williams  | 01:12:23    | 00:10:12        | 00:01:45 | 00:38:14         | 00:01:22 | 00:20:50       |
| David      | Hall      | 01:12:34    | 00:11:14        | 00:01:01 | 00:37:09         | 00:00:48 | 00:22:22       |
| Philip     | Morton    | 01:13:01    | 00:10:57        | 00:01:48 | 00:37:14         | 00:00:46 | 00:22:16       |
| Rowen      | Grandison | 01:13:41    | 00:14:21        | 00:01:22 | 00:35:27         | 00:01:08 | 00:21:23       |
| Matt       | Battensby | 01:13:55    | 00:12:59        | 00:02:22 | 00:37:30         | 00:01:07 | 00:19:57       |
| Robert     | Grande    | 01:14:28    | 00:13:02        | 00:01:34 | 00:37:01         | 00:00:44 | 00:22:07       |
| John       | Percy     | 01:14:28    | 00:12:33        | 00:01:36 | 00:35:41         | 00:01:14 | 00:23:24       |
| John       | Whateley  | 01:14:53    | 00:11:29        | 00:01:48 | 00:37:58         | 00:01:01 | 00:22:37       |
| Tom        | Dailey    | 01:14:54    | 00:10:59        | 00:01:35 | 00:38:39         | 00:00:55 | 00:22:46       |
| Daniel     | Bent      | 01:14:56    | 00:14:46        | 00:01:52 | 00:35:56         | 00:01:16 | 00:21:06       |
| Andrew     | Coe       | 01:14:57    | 00:12:24        | 00:01:39 | 00:35:36         | 01:01:30 | 00:23:48       |
| Rory       | Taylor    | 01:14:59    | 00:11:08        | 00:01:52 | 00:38:22         | 00:00:57 | 00:22:40       |
| Robert     | Wilkinson | 01:15:03    | 00:11:38        | 00:01:50 | 00:37:17         | 00:00:56 | 00:23:22       |
| Alexandra  | Houghton  | 01:15:27    | 00:10:20        | 00:01:15 | 00:35:52         | 00:01:00 | 00:27:00       |
| Scott      | Pryde     | 01:15:32    | 00:11:18        | 00:02:13 | 00:40:32         | 00:01:14 | 00:20:15       |

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