INSTITUTE AND FACULTY OF ACTUARIES

Curriculum 2019

SPECIMEN EXAMINATION

Subject CP2 – Actuarial Modelling

Paper One

Time allowed: Three hours and fifteen minutes

INSTRUCTIONS TO THE CANDIDATE

1. *You must build your model from the beginning and not use an imported e-template.*

This paper contains all of the information required to complete the exam. No other files are supplied.

Your file names must include your ARN, the name of the document and the paper sat (e.g. 9000000-Summary-Paper1) and each file should contain your ARN as a header or footer.

Please note that the content of this booklet is confidential and students are not to discuss or reveal the contents under any circumstances nor are they to be used in a further attempt at the exam.

If you encounter any issues during the examination please contact the Online Education team at online_exams@actuaries.org.uk T. 0044 (0) 1865 268 255

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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.   [10]

   (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 λ 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   **[33]**
   Demonstration of good modelling technique and practice   **[7]**
   Other (non-data) checks   **[7]**

   [Sub-total 47]

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** **[13]**

[Sub-total 53]

[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:

- λ 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 λ 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 λ 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.

Additional guidance

Units

You may want to use the number format type hh:mm:ss. (In the "Format Cells" window, this is in the "custom" category.) This will ensure that the results recorded are easy to interpret, rather than using decimal numbers of hours or minutes.

Speed = distance / time

If the time is currently shown in the format hh:mm:ss then it can be converted to a proportion of an hour by dividing by 1 hour (i.e. divide by 01:00:00). You can enter 01:00:00 into a cell and divide by the contents of that cell. Hence the speed is given by:

distance of stage ÷ [(time taken for competitor to complete the stage)/1 hour]

Transition times

You will need to make an assumption about the transition times in the Minister's triathlon.

For example, you may decide to make the transition times vary depending on the length of the preceding stage of the triathlon or you may decide that they should be unchanged.

Useful Excel functions

The **RANK()** function in Excel can be used to return the ranking of a cell within an unsorted array of numbers. For example, RANK [cell, array, 0] will return the ranking that the number in the given cell would have if the (unsorted) array was sorted into descending order. And RANK[cell, array, 1] will take a similar approach but assuming it was sorted into ascending order.

The **QUARTILE()** function in Excel returns the result at each quartile point, within an unsorted array of numbers. For example, QUARTILE[array, 0] will return the minimum value and QUARTILE[array, 1] will return the value of the first quartile.

Goal Seek

If you are using Goal Seek to solve to an exact target figure and it is failing to find a solution, try changing the variable cell manually instead.

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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
Roberta	Johnson	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00
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
Bertha	Jansch	99:99:99	00:10:23	00:01:56	99:99:99	99:99:99	99:99:99

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