Cambridge International Examinations
Cambridge International Advanced Level

THINKING SKILLS **9694/31**

Paper 3 Problem Analysis and Solution **May/June 2014**

1 hour 30 minutes

Additional Materials: Electronic Calculator

READ THESE INSTRUCTIONS FIRST

An answer booklet is provided inside this question paper. You should follow the instructions on the front cover of the answer booklet. If you need additional answer paper ask the invigilator for a continuation booklet.

Answer **all** the questions.
Calculators should be used where appropriate.

The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **7** printed pages, **1** blank page and **1** insert.

CAMBRIDGE
International Examinations

[Turn over

1 *Study the information below and answer the questions. Show your working.*

Gloria, an antiques dealer, has acquired a collection of sets of Russian dolls. Each set is made up of a number of similar dolls which fit one inside the other. She is trying to work out how many dolls must be in each set, but she does not want to open them because this will reduce their value.

She knows that the manufacturers always obey the following rules:

- there are always at least two dolls in a set;
- the width of the innermost doll is always a whole number of centimetres;
- the widths of the other dolls are the consecutive multiples of this number.

For example, the innermost doll could have a width of 3 cm, in which case the other dolls in the set would have widths of 6 cm, 9 cm, 12 cm etc.

Gloria knows that, for any doll, the weight in grams is equal to the square of the width in centimetres. So, dolls with widths of 4 cm, 8 cm and 12 cm would have weights of 16 g, 64 g and 144 g, and therefore the total weight would be 224 g.

(a) Gloria has one set with an outermost doll of width 20 cm. List all the different possible numbers of dolls in this set. [2]

(b) What is the total weight of the heaviest set of dolls whose outermost width measures 6 cm? [1]

(c) She is able to determine whenever a set is made up of only two dolls. What total weights, less than 100 g, could such a set of dolls have? [2]

(d) What are the four lightest total weights that a set of dolls could have? [3]

After a number of measurements, Gloria realises that her measuring scales are not always accurate, but the error is never more than 1 g. For example, a set of dolls weighing 180 g might register as 179 g, 180 g or 181 g.

(e) Describe two sets of dolls which might not be distinguished by their weights as registered on Gloria's measuring scales. [2]

2 *Study the information below and answer the questions. Show your working.*

Elections in France always take place on Sundays, and people are often called upon to vote on two consecutive Sundays. Voting is voluntary. On each Sunday people may only vote for one candidate in that round.

In the first round, a candidate who gets **more than half of the votes cast** is elected, so long as these were the votes of **at least a quarter of the electorate**. (The electorate consists of all the people entitled to vote.)

Otherwise, there is a second vote, restricted to the two candidates from the first round with the two highest numbers of votes, and any other candidate who had a first-round vote of **at least an eighth of the electorate**. The candidate with the most votes in the second round is elected. A candidate may withdraw after the first round, and the second round only happens if there are still at least two candidates.

The threshold of an eighth used to be a tenth.

The people in Cambronne-sur-Pierre had to vote on the second Sunday. They were annoyed to find that there were exactly the same three candidates as on the first Sunday.

(a) Give an example of percentages of the electorate voting for each of the three candidates on the first Sunday that could have led to this situation. [1]

Assume for the rest of this question that no two candidates in a round get exactly the same number of votes, and that the electorate contains at least 30 000 people.

(b) (i) What is the theoretical maximum possible number of candidates in the second round? [1]

(ii) What was the theoretical maximum possible number of candidates in the second round before the threshold was changed? [1]

The first round votes in an election several years ago, when the threshold was still a tenth, were:

Alain	Bernard	Clothard	David	Emile
4273	53	5370	10 502	651

David was not elected on the first Sunday, and a second round was held.

(c) (i) Which rule stopped David from being elected on the first Sunday? [1]

(ii) What does this indicate about the number of people entitled to vote who did not vote? [2]

(iii) Alain qualified for the second round. What does this indicate about the size of the electorate? [2]

There were, in fact, 42 070 people entitled to vote. If Bernard had not been a candidate, 22 of his voters would have voted for David, and the rest for Alain.

(d) What difference, if any, would that have made? Explain your answer briefly. [2]

3 *Study the information below and answer the questions. Show your working.*

A physics teacher wants her students to investigate how the moon affects the ocean tides, and builds a simple model for doing this. The model involves a square tray split into four compartments, which is able to rotate horizontally. She places 10 water balloons in each of the compartments and then stands at the front of the room, representing the moon. One student stands at each corner of the model with instructions as to how many balloons should be moved to the next compartment, towards the teacher.

The movement of balloons is illustrated in the following diagram, with the arrows showing how many balloons each of the students transfers.
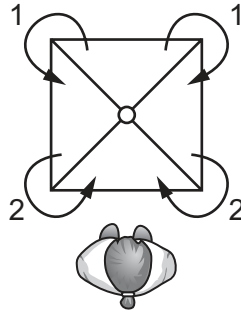
First the tray is turned 90° **anticlockwise**, then the balloons are moved. This process is repeated several times.

After the balloons have been moved for the first time there will be 14 balloons in the compartment closest to the teacher.

(a) How many balloons will be in each of the other compartments at this moment?   [1]

The tray then turns another 90° anticlockwise, and the balloons are again moved.

(b) (i) Draw a diagram showing the number of balloons now in each compartment.   [1]

    (ii) Draw two further diagrams showing the number of balloons in each compartment after the next two times the balloons have been moved.   [2]

The teacher decides to consider the effects of changing the numbers of balloons that are moved each time.

(c) In the diagram below, the tray on the left is turned and then the balloons are moved, resulting in the tray on the right.
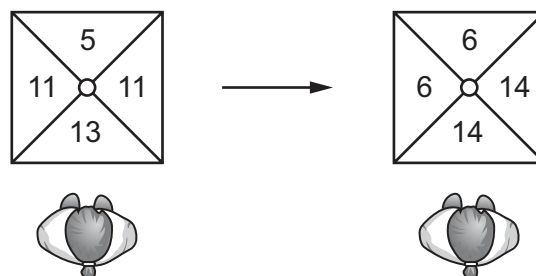
Draw a diagram to show an example of the numbers of balloons that might have been moved between the compartments.   [3]

After each movement of balloons, the teacher draws a diagram showing the number of balloons in each compartment, with the compartment closest to her at the bottom of the diagram. She wants to find a situation in which the diagram is identical each time. She describes such a situation as a 'stable' one.

She decides on the balloon movements shown in the diagram below.
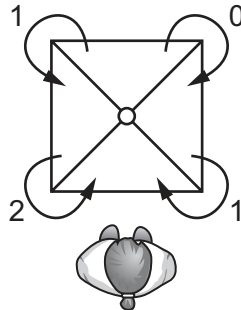
(d) How must a total of 18 balloons be distributed among the compartments in order to achieve a stable situation? [3]

In another example of a stable situation, the teacher's diagram is as shown below.
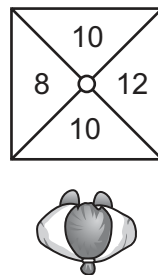
(e) What movements of balloons must be taking place between the four compartments? [2]

(f) Suggest movements of balloons which would lead to a stable situation for the tray shown below. This tray has six compartments and each turn is 60° anticlockwise.
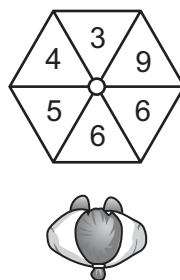
[3]

4 *Study the information below and answer the questions. Show your working.*

Empuda is a sport that resembles tennis, in that two players compete against each other by hitting a ball over a net.

An empuda match consists of 20 *strands*. Each strand begins when one player delivers the ball, and continues until someone scores a *grod*, a *torf* or a *lenk*. The deliverer alternates from strand to strand, and the number of points scored depends upon whether the winner of the strand is the deliverer or the recipient, as detailed below.

Winner of Strand	Points Scored		
	Grod	Torf	Lenk
Deliverer	1	3	5
Recipient	2	5	9

(a) (i) What is the greatest number of points that one player can score in an empuda match? [1]

(ii) What is the greatest possible number of points that a player can win an empuda match by, having won fewer strands than the loser? [2]

Eight players are competing today at Nyhope Empuda Club for the Rulane Cup. The competition is organised as a league, with all the participants playing each other once. League positions are decided by the number of matches won. Where two or more participants have the same number of wins, the total number of points scored overall becomes the deciding factor.

Today's Order of Play, and a summary of each player's performances in matches completed so far, are as follows.

Time	Court 1	Court 2	Court 3
09:00	Serrar v Walker	Baggs v Lyne	Feaver v Shaw
09:50	Feaver v Serrar	Lyne v Walker	Brow v Knutt
10:40	Baggs v Brow	Feaver v Walker	Knutt v Shaw
11:30	Brow v Lyne	Serrar v Shaw	Baggs v Knutt
12:20	Baggs v Feaver	Knutt v Serrar	Brow v Walker
13:10	---------------	Lyne v Shaw	---------------
14:00	Shaw v Walker	Knutt v Lyne	Brow v Feaver
14:50	Knutt v Walker	Feaver v Lyne	Baggs v Serrar
15:40	Brow v Serrar	Baggs v Shaw	Feaver v Knutt
16:30	Lyne v Serrar	Baggs v Walker	Brow v Shaw

	Points Scored Against:							
	Baggs	Brow	Feaver	Knutt	Lyne	Serrar	Shaw	Walker
T. Baggs	╳	32	18	37	22			
I. Brow	41	╳		57	40			47
A. Feaver	34		╳			22	45	36
P. Knutt	33	48		╳		43	32	
B. Lyne	49	20			╳			32
K. Serrar			39	24		╳	36	45
C. Shaw			27	32	18		╳	
J. Walker		12	24		41	38		╳

(b) Which **two** players will **not** play on all three courts today? [1]

Normally, when both players have the same score after 20 strands, 2 further strands are played (and again if necessary) until a winner emerges. In today's event, however, due to time constraints, a tied match counts as a win for both players.

(c) One of the matches played earlier today was tied. Which two players both registered a win as a result? [1]

The highest-scoring match so far today has been Ian Brow's 57–48 defeat of Philip Knutt. The points scored by the two players were as follows:

	Brow	Knutt
9 points	5	4
5 points	0	1
3 points	2	1
2 points	2	1
1 point	2	2

(d) There was only one strand in which 5 points were scored. Did Philip Knutt win this strand with a lenk or a torf? Explain your answer. [3]

(e) In the match currently being played, Craig Shaw has made a spectacular start and now leads Brett Lyne 33–0 after 6 strands.

How many grods, how many torfs and how many lenks has Craig scored? [4]

(f) Ian Brow is the only player to have won all of his matches so far, and consequently he is top of the league at present.

Who is currently in second place, and who is currently in third place? [3]

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