PISA Problem Solving Items and Scoring Guides

The *Problem Solving Items and Scoring Guides* document contains 10 problem solving assessment units and 19 items associated with these units. These released items from the PISA 2003 assessment are distinct from the secure items, which are kept confidential so that they may be used in subsequent cycles to monitor trends.

TABLE OF CONTENTS

MOVIE OUTING

This problem is about finding a suitable time and date to go to a movie.

Isaac, a 15-year-old, wants to organize a movie outing with two of his friends, who are of the same age, during the one-week school vacation. The vacation begins on Saturday March 24th and ends on Sunday April 1st.

Isaac asks his friends for suitable dates and times for the outing. The following information is what he received.

Fred: *"I have to stay home on Monday and Wednesday afternoons for music practice between 2:30 and 3:30"*

Stanley: *"I've to visit grandmother on Sundays, so it can't be Sundays. I have seen Pokamin and don't want to see it again."*

Isaac's parents insist that he only goes to movies suitable for his age and does not walk home. They will pick up the boys any time up to 10 p.m.

Isaac checks the movie times for the vacation week. This is the information that he finds.

TIVOLI MOVIE THEATER	
Advance Booking Number: 919-545-6400	
24 hour phone number: 919-545-6405	
Bargain Day Tuesdays: All films $5	
Films showing from Fri March 23rd for two weeks:	

Children in the Net		Pokamin	
113 mins 2:00 p.m. (Mon-Fri only) 9:35 p.m. (Sat/Sun only)	Suitable only for persons of 12 years and over	105 mins 1:40 p.m. (Daily) 4:35 p.m. (Daily)	Parental Guidance. General viewing, but some scenes may be unsuitable for young children
Monsters from the Deep		**Enigma**	
164 mins 7:55 p.m. (Fri/Sat only)	Suitable only for persons of 18 years and over	144 mins 3:00 p.m. (Mon-Fri only) 6:00 p.m. (Sat/Sun only)	Suitable only for persons of 12 years and over
Carnivore		**King of the Wild**	
148 mins 6:30 p.m. (Daily)	Suitable only for persons of 18 years and over	117 mins 2:35 p.m. (Mon-Fri only) 6:50 p.m.(Sat/Sun only)	Suitable for persons of all ages

Question 1: MOVIE OUTING

Question intent: Decision Making

Taking into account the information Isaac found on the movies, and the information he got from his friends, which of the six movies should Isaac and the boys consider watching?

Circle "Yes" or "No" for each movie.

Movie	Should the three boys consider watching the movie?
Children in the Net	Yes / No
Monsters from the Deep	Yes / No
Carnivore	Yes / No
Pokamin	Yes / No
Enigma	Yes / No
King of the Wild	Yes / No

SCORING

Fully Correct

Yes, No, No, No, Yes, Yes, in that order.

Partially Correct

One incorrect answer.

Incorrect

Other responses.

Percentage of students answering correctly in PISA 2003: OECD average: 68% U.S.: 67%

Question 2: MOVIE OUTING

Question intent: Decision Making

If the three boys decided on going to "Children in the Net," which of the following dates is suitable for them?

A   Monday, March 26th
B   Wednesday, March 28th
C   Friday, March 30th
D   Saturday, March 31st
E   Sunday, April 1st

SCORING

Correct

Answer C. Friday, March 30th.

Incorrect

Other responses.

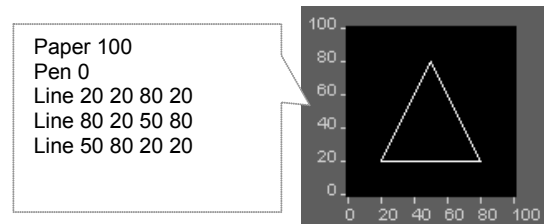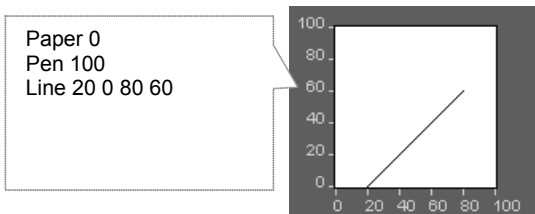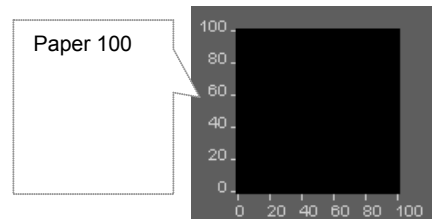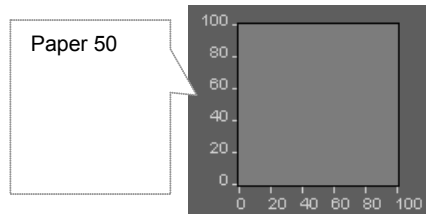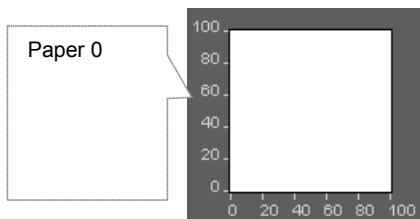| Percentage of students answering correctly in PISA 2003: |
| --- |
| OECD average: 68%
 U.S.: 67% |

DESIGN BY NUMBERS©

Design by Numbers is a design tool for generating graphics on computers. Pictures can be generated by giving a set of commands to the program.

Study carefully the following example commands and pictures before answering the questions.

Paper 0

Paper 50

Paper 100

Paper 0
Pen 100
Line 20 0 80 60

Paper 100
Pen 0
Line 20 20 80 20
Line 80 20 50 80
Line 50 80 20 20

Question 1: DESIGN BY NUMBERS

Question intent: System Analysis and Design

Which of the following commands generated the graphic shown below?

A   Paper 0
B   Paper 20
C   Paper 50
D   Paper 75

SCORING

Correct

Answer B. Paper 20.

Incorrect

Other responses.

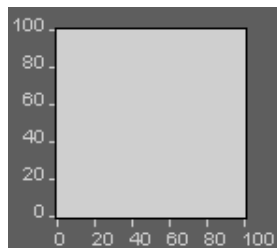| **Percentage of students answering correctly in PISA 2003:** |
| --- |
| OECD average: 51%
 U.S.: 41% |

Question 2: DESIGN BY NUMBERS

Question intent: System Analysis and Design

Which of the following set of commands generated the graphic shown below?

A	Paper 100	Pen 0	Line 80 20 80 60
B	Paper 0	Pen 100	Line 80 20 60 80
C	Paper 100	Pen 0	Line 20 80 80 60
D	Paper 0	Pen 100	Line 20 80 80 60

SCORING

Correct

Answer D. Paper 0 Pen 100 Line 20 80 80 60

Incorrect

Other responses.

Percentage of students answering correctly in PISA 2003:

OECD average: 49%
U.S.: 47%

8

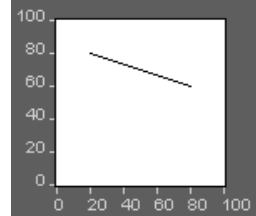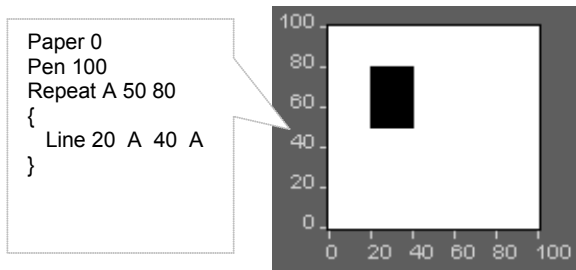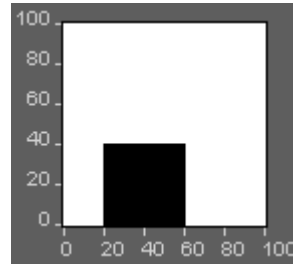## Question 3: DESIGN BY NUMBERS

Question intent: System Analysis and Design

The following shows an example of the "Repeat" command.

```
Paper 0
Pen 100
Repeat A 50 80
{
   Line 20  A  40  A
}
```


The command "Repeat A 50 80" tells the program to repeat the actions in brackets { }, for successive values of A from A=50 to A=80.

Write commands to generate the following graphic:

SCORING

Fully Correct

Correct commands.

- Note that in the "Repeat" command, "0" and "40" can be switched (i.e., Repeat 40 0). In the command "Line 20 A 60 A", "20" and "60" can be switched (i.e., Line 60 A 20 A).

  ```
  Paper 0
  Pen 100
  Repeat A 0 40
  {
    Line 20 A 60 A
  }
  ```

- Note that in the "Repeat" command, "20" and "60" can be switched (i.e., Repeat 60 20). In the command "Line A 0 A 40", "0" and "40" can be switched (i.e., Line A 40 A 0).
  ```
  Paper 0
  Pen 100
  Repeat A 20 60
  {
    Line A 0 A 40
  }
  ```

(In short, "0" and "40" should be in the "Y" position and "20" and "60" should be in the "X" position.)

Partially Correct

Correct commands but incorrect placement of numbers in the Line command.

```
☐ Paper 0
Pen 100
Repeat A 20 60
{
  Line 0 A 40 A
}
```

Correct commands but one incorrect number in either the Repeat or the Line command. Note that if there is any number other than 0 or 20 or 40 or 60 (e.g., 50 or 80 are used), or if the same number is repeated in the one command, then Code 0 should be given.

Incorrect

Other responses.

Percentage of students answering correctly in PISA 2003:

OECD average: 40%
U.S.: 31%

TRANSIT SYSTEM

The following diagram shows part of the transportation system of a city in Zedland, with three railway lines. It shows where you are now, and where you have to go.
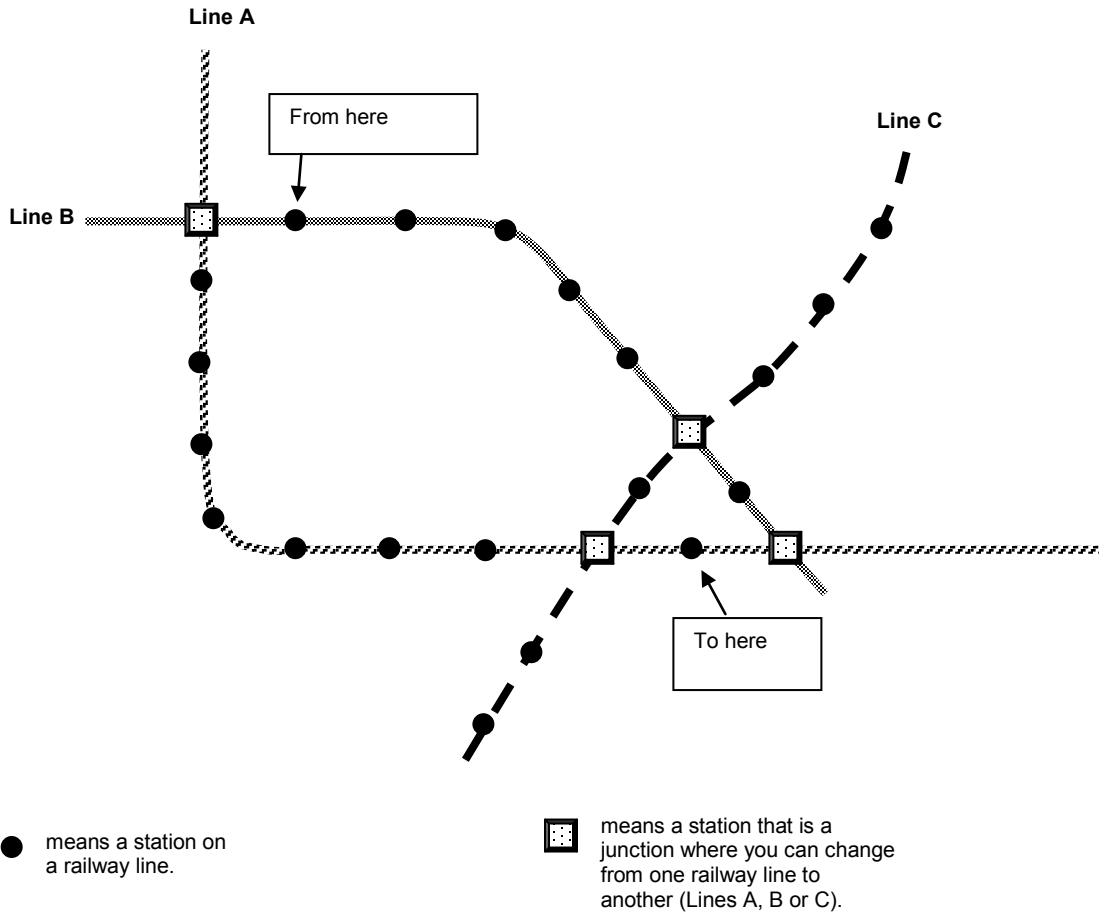
The fare is based on the number of stations travelled (not counting the station where you start your journey). Each station travelled costs 1 zed.

The time taken to travel between two adjacent stations is about 2 minutes.

The time taken to change from one railway line to another at a junction is about 5 minutes.

Question 1: TRANSIT SYSTEM

Question intent: Decision Making

The diagram indicates a station where you are currently at ("From here"), and the station where you want to go ("To here"). **Mark on the diagram** the best route in terms of cost and time, and indicate below the fare you have to pay, and the approximate time for the journey.

Fare: .... zeds.

Approximate time for journey: .... minutes.

SCORING

Fully Correct

Route as shown: Fare: 8 zeds: Approximate time for journey: 21 minutes.
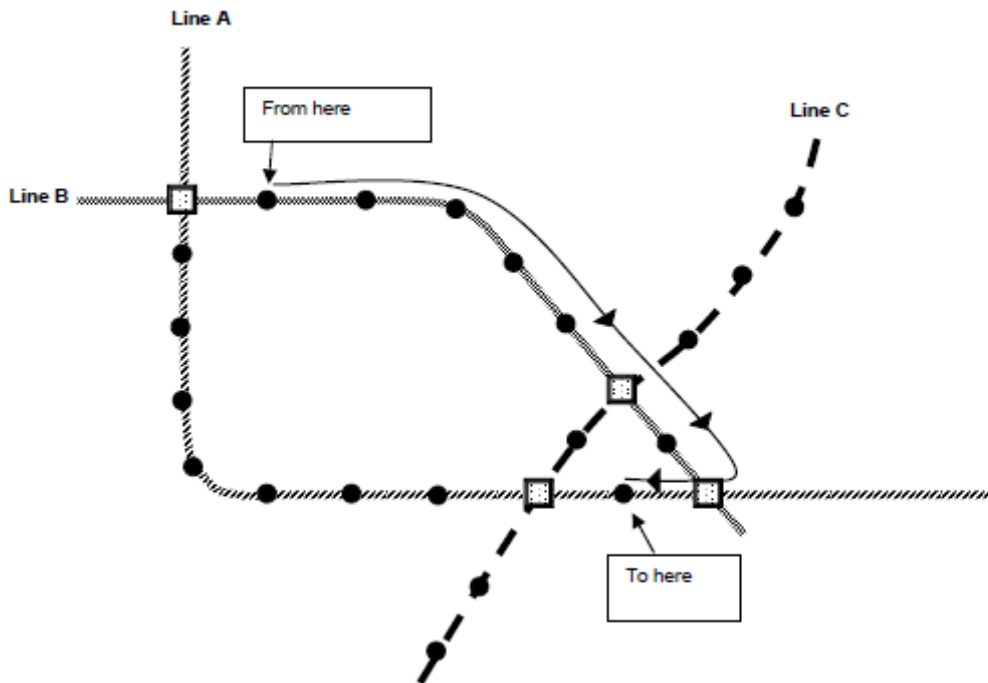
No route shown; Fare: 8 zeds; Time: 21 minutes.

Partially Correct

Best route shown, with correct Fare or Time, but not both.

One of the two other possible routes shown, with correct Fare and Time for that route.

No route shown, but correct Fare **and** Time for one of the two other routes are given.

Incorrect

Best route shown, but both Fare and Time incorrect or missing

Other responses.

Percentage of students answering correctly in PISA 2003:
OECD average: 24% U.S.: 15%

COURSE DESIGN

A technical college offers the following 12 subjects for a 3-year course, where the length of each class is one year:

	Class Code	Class Name
1	M1	Mechanics Level 1
2	M2	Mechanics Level 2
3	E1	Electronics Level 1
4	E2	Electronics Level 2
5	B1	Business Studies Level 1
6	B2	Business Studies Level 2
7	B3	Business Studies Level 3
8	C1	Computer Systems Level 1
9	C2	Computer Systems Level 2
10	C3	Computer Systems Level 3
11	T1	Technology and Information Management Level 1
12	T2	Technology and Information Management Level 2

Question 1: COURSE DESIGN

Question intent: System Analysis and Design

Each student will take 4 classes per year, thus completing 12 subjects in 3 years.

A student can only take a class at a higher level if the student has completed the lower level(s) of the same class in a previous year. For example, you can only take Business Studies Level 3 after completing Business Studies Levels 1 and 2.

In addition, Electronics Level 1 can only be taken after completing Mechanics Level 1, and Electronics Level 2 can only be taken after completing Mechanics Level 2.

Decide which classes should be offered for which year, by completing the following table. Write the class codes in the table.

	Class 1	Class 2	Class 3	Class 4
Year 1				
Year 2				
Year 3				

SCORING

Fully Correct

The order of classes within a year is unimportant, but the list of classes for each year should be as given below:

- **Year 1** B1 M1 T1 C1
- **Year 2** B2 M2 E1 C2
- **Year 3** B3 T2 E2 C3

Partially Correct

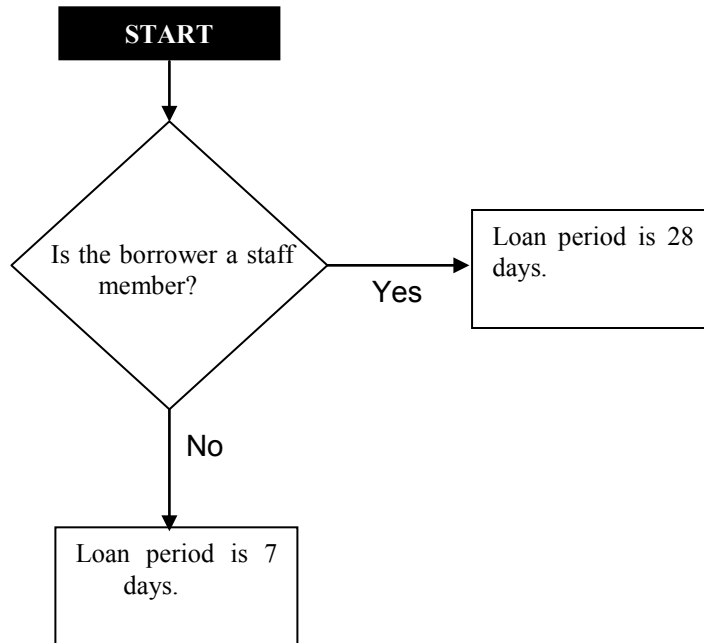Mechanics does not precede Electronics. All other constraints are satisfied.

Incorrect

Other responses.

Percentage of students answering correctly in PISA 2003: OECD average: 32% U.S.: 33%

LIBRARY SYSTEM

The **John Hobson High School** library has a simple system for lending books: for staff members the loan period is 28 days, and for students the loan period is 7 days. The following is a decision tree diagram showing this simple system:

```
                    ┌─────────────┐
                    │    START    │
                    └──────┬──────┘
                           │
                           ▼
                         ╱   ╲
                        ╱     ╲                    ┌──────────────────┐
                       ╱  Is the ╲        Yes      │ Loan period is 28│
                      ╱ borrower a ╲──────────────▶│ days.            │
                       ╲ staff     ╱               └──────────────────┘
                        ╲ member? ╱
                         ╲       ╱
                           │
                           │ No
                           ▼
                    ┌──────────────────┐
                    │ Loan period is 7 │
                    │ days.            │
                    └──────────────────┘
```

The **Greenwood High School** library has a similar, but more complicated, lending system:

- All publications classified as "Reserved" have a loan period of 2 days.

- For books (not including magazines) that are **not** on the reserved list, the loan period is 28 days for staff, and 14 days for students.

- For magazines that are **not** on the reserved list, the loan period is 7 days for everyone.

- Persons with any overdue items are not allowed to borrow anything.

Question 1: LIBRARY SYSTEM

Question intent: System Analysis and Design
You are a student at **Greenwood High School**, and you do not have any overdue items from the library. You want to borrow a book that is **not** on the reserved list. How long can you borrow the book for?

Answer: .... days.

SCORING

Correct

14 days.

Incorrect

Other responses.

Percentage of students answering correctly in PISA 2003:
OECD average: 75% U.S.: 75%

Question 2: LIBRARY SYSTEM

Question intent: System Analysis and Design

Develop a decision tree diagram for the **Greenwood High School Library** system so that an automated checking system can be designed to deal with book and magazine loans at the library. Your checking system should be as efficient as possible (i.e. it should have the least number of checking steps). Note that each checking step should have only **two** outcomes and the outcomes should be labelled appropriately (e.g. "Yes" and "No").
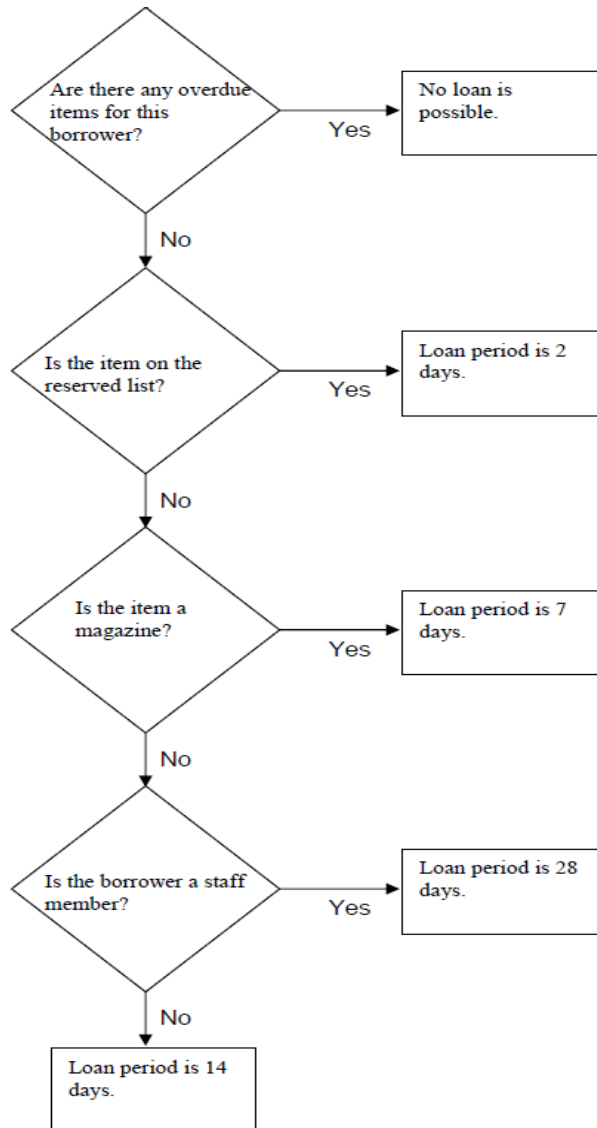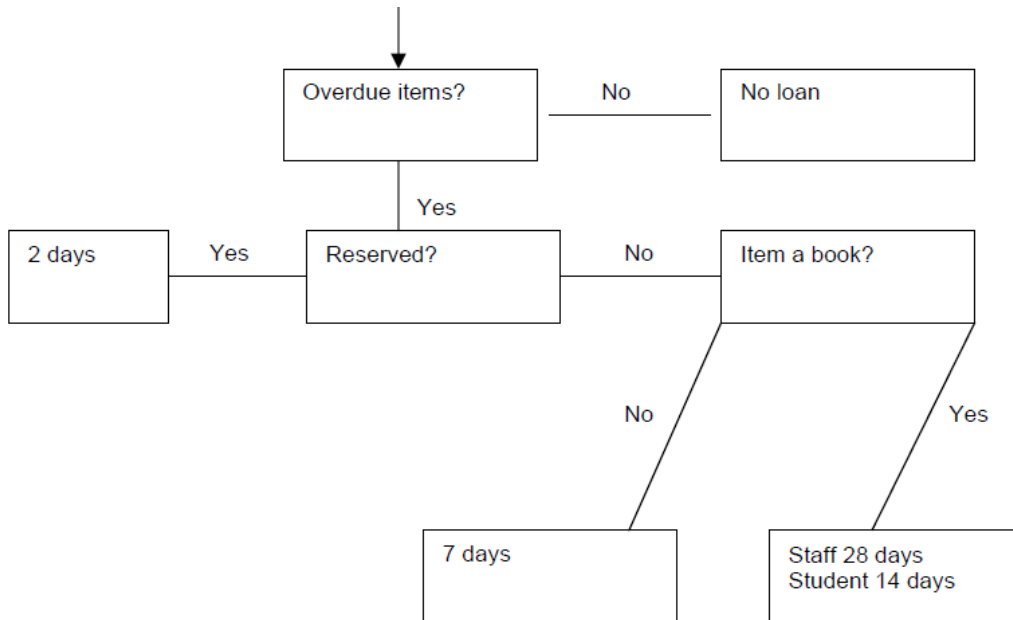
START

SCORING

Fully Correct

The most efficient system is a 4-step check system as follows:

Partially Correct

The four check steps are in the right sequence, but there is a "minor error":

- The check for "overdue items" is written as a statement outside the decision tree diagram, but the other three check steps are completely correct and in the right sequence.
- Two check steps are out of order, resulting in 5 steps, as ONE extra check step is required. The system is still "complete", but less efficient. By "complete" we mean that the checking system will produce the correct loan periods in all cases.
- The diagram is correct except that the first three check steps are out of order in one (but not both) of the following two ways:
  - The check for "overdue items" is written as a statement outside the decision tree diagram. The other three check steps are in the right sequence, but with a "minor error".
  - The check for "overdue items" is missing, but the other three check steps are completely correct and in the right sequence.

Incorrect

The system is "complete", but has more than 5 check steps.

Other responses.

Percentage of students answering correctly in PISA 2003:
OECD average: 15% U.S.: 14%

TRIP

This problem is about planning the best route for a trip.

Figures 1 and 2 show a map of the area and the distances between towns.

Figure 1: Map of roads between towns.
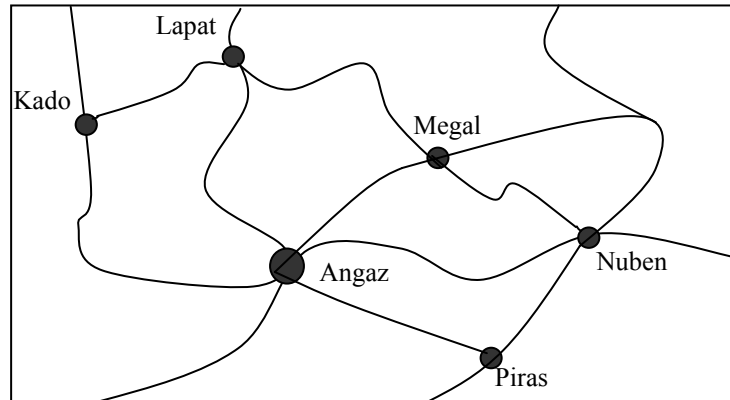
Figure 2: Shortest road distance of towns from each other in kilometres.

	Angaz	Kado	Lapat	Megal	Nuben	Piras
Angaz						
Kado	550					
Lapat	500	300				
Megal	300	850	550			
Nuben	500		1000	450		
Piras	300	850	800	600	250	

Question 1: TRIP

Question intent: Decision Making

Calculate the shortest distance by road between Nuben and Kado.

Distance:.. kilometers.

SCORING

Correct

1050 kilometers

Incorrect

Other responses.

Percentage of students answering correctly in PISA 2003:
OECD average: 46% U.S.: 37%

Question 2: TRIP

Question intent: Decision Making

Zoe lives in Angaz. She wants to visit Kado and Lapat. She can only travel **up to 300 kilometres** in any one day, but can break her journey by camping overnight anywhere between towns.

Zoe will stay for **two nights** in each town, so that she can spend one whole day sightseeing in each town.

Show Zoe's itinerary by completing the following table to indicate where she stays each night.

Day	Overnight Stay
1	Camp-site between Angaz and Kado.
2	
3	
4	
5	
6	
7	Angaz

SCORING

Fully Correct

Entries as shown below:

Day	Overnight Stay
1	Camp-site between Angaz and Kado.
2	Kado
3	Kado
4	Lapat
5	Lapat
6	Camp-site between Lapat and Angaz (OR just "Camp-site")
7	Angaz

Partially Correct

One error. An error means the entry is not correct for the corresponding day.

Incorrect

Other responses.

| **Percentage of students answering correctly in PISA 2003:**

OECD average: 36%
U.S.: 33% |
|---|

IRRIGATION

Below is a diagram of a system of irrigation channels for watering sections of crops. The gates A to H can be opened and closed to let the water go where it is needed. When a gate is closed no water can pass through it.

This is a problem about finding a gate which is stuck closed, preventing water from flowing through the system of channels.

Figure 1: A system of irrigation channels
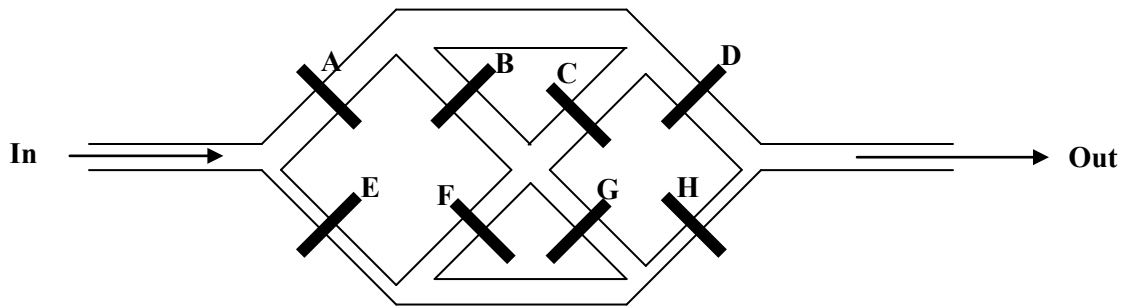
Michael notices that the water is not always going where it is supposed to.

He thinks that one of the gates is stuck closed, so that when it is switched to "open", it does not open.

Question 1: IRRIGATION

Question intent: Trouble Shooting

Michael uses the settings given in Table 1 to test the gates.

Table 1: Gate Settings

A	B	C	D	E	F	G	H
Open	Closed	Open	Open	Closed	Open	Closed	Open

With the gate settings as given in Table 1, **on the diagram below** draw all the possible paths for the flow of water. Assume that all gates are working according to the settings.
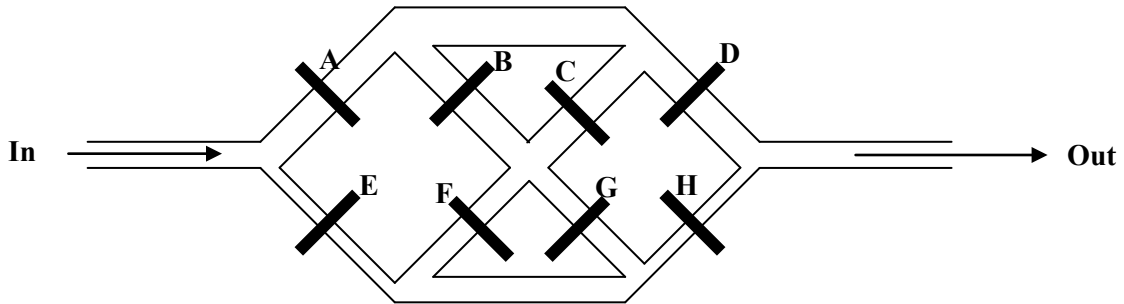
SCORING

Correct

Flow paths as shown below:

Incorrect

Other responses.

Percentage of students answering correctly in PISA 2003:
OECD average: 63% U.S.: 58%

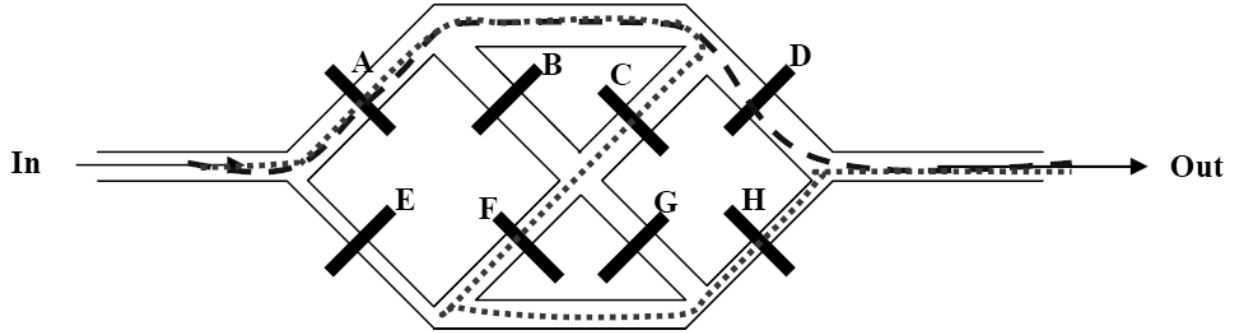## Question 2: IRRIGATION

Question intent: Trouble Shooting

Michael finds that, when the gates have the Table 1 settings, no water flows through, indicating that at least one of the gates set to "open" is stuck closed.

Decide for each problem case below whether the water will flow through all the way. Circle "Yes" or "No" in each case.

Problem Case	Will water flow through all the way?
Gate **A** is stuck closed. All other gates are working properly as set in Table 1.	Yes / No
Gate **D** is stuck closed. All other gates are working properly as set in Table 1.	Yes / No
Gate **F** is stuck closed. All other gates are working properly as set in Table 1.	Yes / No

SCORING

Correct

No, Yes, Yes, in that order.

Incorrect

Other responses.

Percentage of students answering correctly in PISA 2003: OECD average: 52% U.S.: 45%

Question 3: IRRIGATION

Question intent: Trouble Shooting
Michael wants to be able to test whether **gate D** is stuck closed.

In the following table, show settings for the gates to test whether **gate D** is stuck closed when it is set to "open".

Settings for gates (each one "open" or "closed")

A	B	C	D	E	F	G	H

SCORING

Correct

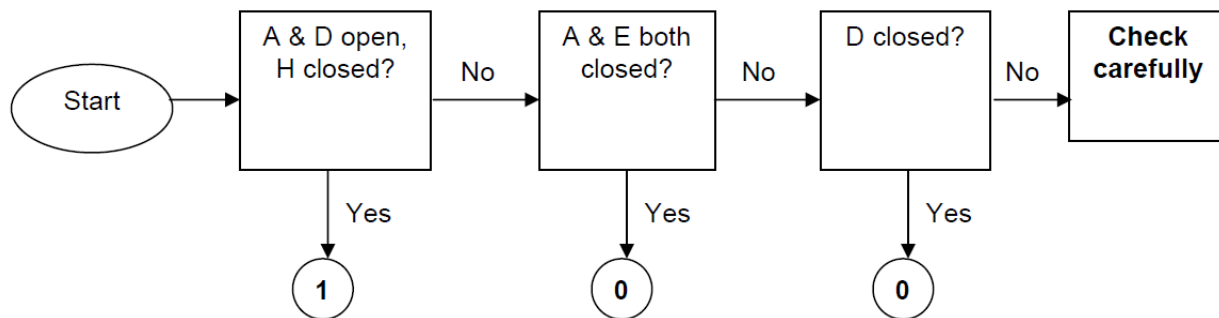A and E are not both closed. D must be open. H can only be open if water cannot get to it (e.g., other gates are closed preventing water from X603Irrig_ENG3.doc reaching H). Otherwise H must be closed.

Incorrect

Other responses.

The following is a diagram to help you assign codes to students' responses:

Percentage of students answering correctly in PISA 2003:

OECD average: 55%
U.S.: 52%

ENERGY NEEDS

This problem is about selecting suitable food to meet the energy needs of a person in Zedland. The following table shows the recommended energy needs in kilojoules (kJ) for different people. [NOTE: A kilojoule is the metric unit for energy, similar to a Calorie.]

DAILY ENERGY NEEDS RECOMMENDED FOR ADULTS

		MEN	WOMEN
Age (years)	**Activity Level**	**Energy Needed (kJ)**	**Energy Needed (kJ)**
From 18 to 29	Light Moderate Heavy	10660 11080 14420	8360 8780 9820
From 30 to 59	Light Moderate Heavy	10450 12120 14210	8570 8990 9790
60 and above	Light Moderate Heavy	8780 10240 11910	7500 7940 8780

ACTIVITY LEVEL ACCORDING TO OCCUPATION

Light:	**Moderate:**	**Heavy:**
Indoor sales person	Teacher	Construction worker
Office worker	Outdoor salesperson	Laborer
Housewife	Nurse	Sportsperson

Question 1: ENERGY NEEDS

Question intent: Decision Making

Mr. David Edison is a 45-year-old teacher. What is his recommended daily energy need in kJ?

Answer:................................. kilojoules.

SCORING

Correct

12120 kilojoules. If no answer is given, check whether the student circled "12120" in the table.

Incorrect

Other responses.

| **Percentage of students answering correctly in PISA 2003:** |
| OECD average: 85% |
| U.S.: 60% |

Jane Gibbs is a 19-year-old high jumper. One evening, some of Jane's friends invite her out for dinner at a restaurant. Here is the menu.

MENU		Jane's estimate of energy per serving (kJ)
Soups:	Tomato Soup	355
	Cream of Mushroom Soup	585
Main courses:	Mexican Chicken	960
	Caribbean Ginger Chicken	795
	Pork and Sage Kebabs	920
Salads:	Potato Salad	750
	Spinach, Apricot and Hazelnut Salad	335
	Couscous Salad	480
Desserts:	Apple and Raspberry Crumble	1380
	Ginger Cheesecake	1005
	Carrot Cake	565
Milk shakes:	Chocolate	1590
	Vanilla	1470

The restaurant also has a special fixed price menu.

Fixed Price Menu
50 zeds
Tomato Soup
Caribbean Ginger Chicken
Carrot Cake

Question 2: ENERGY NEEDS

Question intent: Decision Making

Jane keeps a record of what she eats each day. Before dinner on that day her total intake of energy had been 7520 kJ.

Jane does **not** want her total energy intake to go **below or above her recommended daily amount** by more than 500 kJ.

Decide whether the special "Fixed Price Menu" will allow Jane to stay within ±500 kJ of her recommended energy needs. Show your work.

SCORING

Fully Correct

Food from the fixed price menu does not contain enough energy for Jane to keep within 500 kJ of her energy needs. The following steps are necessary:

1. Calculation of the total energy of the fixed price menu: 355+795+565=1715
2. Recognition that Jane's daily recommended energy need is 9820 k
3. Use of 7520 with 1715 and 9820, showing that Jane would be more than 500 kJ below her recommended energy need
4. Conclusion that the fixed price menu does not contain enough energy

Partially Correct

Correct method, but a minor error or omission in one of the calculation steps leading to a correct or incorrect, but consistent, conclusion.

1715+7520=9235. This is within 500 of 8780, so "Yes"

Correct calculations, but concludes "Yes" or gives no conclusion

Incorrect

Other responses, including "No", without explanation.

Correct reasoning in words but no figures shown.

Percentage of students answering correctly in PISA 2003:
OECD average: 32% U.S.: 27%

CHILDREN'S CAMP

The Zedish Community Service is organizing a five-day Children's Camp. 46 children (26 girls and 20 boys) have signed up for the camp, and 8 adults (4 men and 4 women) have volunteered to attend and organize the camp.

Table 1: Adults

Mrs. Madison
Mrs. Carroll
Ms. Grace
Ms. Kelly
Mr. Stevens
Mr. Neill
Mr. Williams
Mr. Peters

Table 2: Dormitories

Name	Number of beds
Red	12
Blue	8
Green	8
Purple	8
Orange	8
Yellow	6
White	6

Dormitory rules:
1. Boys and girls must sleep in separate dormitories.

2. At least one adult must sleep in each dormitory.

3. The adult(s) in a dormitory must be of the same gender as the children.

Question 1: CHILDREN'S CAMP

Question intent: System Analysis and Design

Dormitory Allocation.
Fill the table to allocate the 46 children and 8 adults to dormitories, keeping to all the rules.

Name	Number of boys	Number of girls	Name(s) of adult(s)
Red			
Blue			
Green			
Purple			
Orange			
Yellow			
White			

SCORING

Fullly Correct

6 conditions to be satisfied:
- Total girls = 26
- Total boys = 20
- Total adults = four female and four male
- Total (children and adults) per dormitory is within the limit for each dormitory
- People in each dormitory are of the same gender
- At least one adult must sleep in each dormitory to which children have been allocated

Partially Correct
One or two conditions (mentioned in Code 2) violated. Violating the same condition more than once will be counted as ONE violation only:
- Forgetting to count the adults in the tally of the number of people in each dormitory
- The number of girls and the number of boys are interchanged (no. of girls = 20, no. of boys = 26), but everything else is correct. (Note that this counts as two conditions violated.)
- The correct number of adults in each dormitory is given, but not their names or gender. (Note that this violates both condition 3 and condition 5.)

Incorrect

Other responses.

Percentage of students answering correctly in PISA 2003:
OECD average: 40% U.S.: 35%

FREEZER

Jane bought a new upright freezer. The manual gave the following instructions:

- Connect the appliance to the power and switch the appliance on.

  - You will hear the motor running now.
  - A red warning light (LED) on the display will light up.

- Turn the temperature control to the desired position. Position 2 is normal.

Position	Temperature
1	−15°C
2	−18°C
3	−21°C
4	−25°C
5	−32°C

  - The red warning light will stay on until the freezer temperature is low enough. This will take 1 - 3 hours, depending on the temperature you set.

- Load the freezer with food after four hours.

Jane followed these instructions, but she set the temperature control to position 4. After 4 hours, she loaded the freezer with food.

After 8 hours, the red warning light was still on, although the motor was running and it felt cold in the freezer.

Question 1: FREEZER

Question intent: Trouble Shooting

Jane wondered whether the warning light was functioning properly. Which of the following actions and observations would suggest that the light was working properly?

Circle "Yes" or "No" for each of the three cases.

Action and Observation	Does the observation suggest that the warning light was working properly?
She put the control to position 5 and the red light went off.	Yes / No
She put the control to position 1 and the red light went off.	Yes / No
She put the control to position 1 and the red light stayed on.	Yes / No

SCORING

Correct

No, Yes, No, in that order.

Incorrect

Other responses.

Percentage of students answering correctly in PISA 2003: OECD average: 45% U.S.: 35%

Question 2: FREEZER

Question intent: Trouble Shooting

Jane read the manual again to see if she had done something wrong. She found the following six warnings:

1. Do not connect the appliance to an ungrounded power point.

2. Do not set the freezer temperatures lower than necessary (–18 ^{o}C is normal).

3. The ventilation grills should not be obstructed. This could decrease the freezing capability of the appliance.

4. Do not freeze lettuce, radishes, grapes, whole apples and pears, or fatty meat.

5. Do not salt or season fresh food before freezing.

6. Do not open the freezer door too often.

Ignoring which of these six warnings could have caused the delay in the warning light going out?

Circle "Yes" or "No" for each of the six warnings.

Warning	Could ignoring the warning have caused a delay in the warning light going out?
Warning 1	Yes / No
Warning 2	Yes / No
Warning 3	Yes / No
Warning 4	Yes / No
Warning 5	Yes / No
Warning 6	Yes / No

SCORING

Fully Correct

No, Yes, Yes, No, No, Yes, in that order.

Partially Correct

One error.

Incorrect

Other responses.

Percentage of students answering correctly in PISA 2003:

OECD average: 50%
U.S.: 46%