E-GENTING BUG HUNT 2017

General instructions:

1. Write testing procedures (i.e. a test plan) for the program described below.
2. Your testing procedures must be written in the English language.
3. The competition is an open book test.
4. Electronic aids are not permitted.
5. The duration of the competition is 8 hours.
6. Do not discuss matters related to the competition with other contestants.
7. Your testing procedures may involve.
    - manipulating the inputs of the program and verifying that the correct outputs are produced;
    - inspection of the program to verify that it is programmed correctly;
    - extracting functions or code fragments from the program and putting them in a program of your own creation that exercises the functions or code fragments in a way that would be difficult by manipulating the inputs of the complete program;
    - any other process that verifies that the program is functioning correctly.
8. The words ‘must’, ‘must not’, ‘required’, ‘should’, ‘should not’, and ‘may’ are to be interpreted as described in RFC 2119[1].

[1] *Key words for use in RFCs to Indicate Requirement Levels*, RFC 2119, S. Bradner, March 1997.

1 INTRODUCTION

Crammers College specialises in accepting students who've been somewhat lazy during the early and middle parts of their courses and preparing them for their final exams, if not at the last minute, at least in the last couple of months.

Crammers has observed that many of their students apply the limited time they have left somewhat inefficiently and that they often fixate on a particular subject to the detriment of their average score. In an effort to convince students to apply their time more efficiently, Crammers has devised an algorithm that uses Monte Carlo simulation to recommend, if not the perfect study plan, at least a study plan that's a good deal better than the worst.

This Specification describes Crammers requirements for a program called 'Study Plan' that implements the Monte Carlo simulation algorithm. Your task is to prepare a test plan to verify that Study Plan has been correctly implemented.

2 INPUT FORMAT

Study Plan must receive the following parameters on a data entry screen:

1. start date;
2. number of study periods per day (1 to 12);
3. number of Monte Carlo cycles to execute;
4. for each subject:
    a. subject code;
    b. base permanent knowledge (0 to 100%);
    c. base volatile knowledge (0 to 100%);
    d. incremental permanent knowledge (0 to 100%);
    e. incremental volatile knowledge (0 to 100%);
    f. volatile knowledge half-life (1 to 999 days);
    g. subject weight;
    h. for each exam in the subject:
        i. exam date;
        ii. exam period number.

The start date is the date of the first day in the study schedule. It is the date of the first day on which the student is available to start studying.

Each day is divided into a number of study periods. Typically this would be 3 for morning, afternoon and evening, but it may be more or less depending on the exam schedule and the needs of the student.

The number of Monte Carlo cycles is simply the number of experiments that the model makes in its effort to search for an optimal study plan. At least in theory, the larger the number of Monte Carlo cycles, the more likely it is that the study plan is closer to the optimal study plan.

The subject code is a code that identifies the subject to be studied during a study period.

A student's knowledge is divided into permanent knowledge and volatile knowledge. Permanent knowledge is that component of the student's knowledge that is not lost as a consequence of the elapse of time whereas volatile knowledge is expected to be lost in an exponential decay as time elapses.

The student's knowledge is further divided into base knowledge and incremental knowledge. Base knowledge is the knowledge that the student possesses at the beginning of the study plan whereas incremental knowledge is the knowledge that the student acquires during the study plan.

The student's base permanent and volatile knowledge are the percentages of the subject material that the student possesses at the beginning of the study plan. The permanent component is not lost over time whereas the volatile component is lost over time. For example, if the student fully understood half the material at the beginning of the study plan, but a fifth of that knowledge was volatile and likely to be lost, the student's base permanent knowledge would be 40% and his base volatile knowledge would be 10%.

The student's incremental permanent and volatile knowledge are the percentages of the *remaining* subject material that the student is able to learn in a study period divided into permanent and volatile components. For example, if a student is able to learn a fifth of the remaining material in a study period, but half of that is likely to be lost over time, the student's incremental permanent and volatile knowledge percentages would both be 10%.

The volatile knowledge half-life is the number of days it takes for half of the student's volatile knowledge to be lost. For example, if the student's base permanent and volatile knowledge were 40% and 10% respectively and the student's volatile knowledge half-life was 14 days and the student did not study at all, then after 14 days the student's permanent and volatile knowledge percentages would have diminished to 40% and 5% respectively giving a total of 45%.

The subject weight is a means for giving more importance to certain subjects. For example, if the student wants to continue to further studies in engineering then mathematics, physics and chemistry might be more important than literature and history, whereas if the student intends to study law, the opposite might be true. Subject weights are relative. Conceptually, a subject with a weight of 2 is twice as important as a subject with a weight of 1.

The exam dates are the dates on which the exams in the subject are scheduled. The exam period numbers are the period in the day in which the exam is to occur. Period numbers start at zero for the first period of the day.

3 SAVING AND RESTORING PARAMETERS

Study Plan must have a means to save a configuration of entered parameters in non-volatile storage identified by a file name and having saved the parameters, must have a means to restore the saved parameters back into the data entry fields so that they can be used again without having to enter all the values.

4 OBJECTIVE EQUATION

Study Plan must experiment with assigning different subjects to different study periods and select the combination that minimises the value of the following equation (the 'Objective Equation'):

$$\sum_{i=1}^{n}\left(W_i\frac{\sum_{j=1}^{m_i}\left(100-k_{ij}\right)^2}{m_i}\right)$$

Where:

- i is the subject index.
- n is the total number of subjects.
- j is the exam index.
- m_i is the number of exams in the i-th subject.
- W_i is the weight of the i-th subject.
- k_{ij} is the percentage of the material in the i-th subject that the student possesses at the time of the j-th exam in the subject.

A student's knowledge in the i-th subject at a particular time 't' is given by the following series of formulas:

$$k_{it}=p_{it}+v_{it}$$

$$p_{it}=p_{i(t-1)}+\frac{s_{i(t-1)}Ip_i(100-k_{i(t-1)})}{100}$$

$$v_{it}=E_iv_{i(t-1)}+\frac{s_{i(t-1)}Iv_i(100-k_{i(t-1)})}{100}$$

$$E_i=e^{-\left(\frac{\ln(2)}{Qh_i}\right)}$$

Where:

- i is the subject index
- t is the time in periods (t = 0 is the time at the beginning of the first period in the first day, t = 1 is the time at the beginning of the second period and so forth).
- k_{it} is the student's total knowledge of the material in the i-th subject at time 't' expressed as a percentage.
- p_{it} is the student's permanent knowledge of the material in the i-th subject at time 't' expressed as a percentage.
- p_{i0} is the student's permanent knowledge of the material in the i-th subject at the beginning of the study timetable (i.e. at t=0) and is an input parameter.
- v_{it} is the student's volatile knowledge of the material in the i-th subject at time 't' expressed as a percentage.

v_{i0} is the student's volatile knowledge of the material in the *i*-th subject at the beginning of the study timetable (i.e. at t=0) and is an input parameter.

$p_{i(t-1)}$ is the student's permanent knowledge of the material in the *i*-th subject at the beginning of the previous study period.

$v_{i(t-1)}$ is the student's volatile knowledge of the material in the *i*-th subject at the beginning of the previous study period.

E_i is the amount by which the student's volatile knowledge in the *i*-th subject is diminished with the passing of each study period.

$s_{i(t-1)}$ can be 1 or 0 and is 1 if the student studied the *i*-th subject in the previous period, otherwise it is zero.

Ip_i is the student's incremental permanent knowledge percentage for the *i*-th subject and is an input parameter.

Iv_i is the student's incremental volatile knowledge percentage for the *i*-th subject and is an input parameter.

e is the base of the natural logarithm.

$ln(...)$ is the natural logarithm function.

Q is the number of study periods per day.

h_i is the student's volatile knowledge half-life for the *i*-th subject.

5 SEARCH ALGORITHM

Study Plan must display a button entitled 'Run' that initiates a search for a combination of subjects to study in the available study periods that minimises the value of the Objective Equation.

The search must proceed as follows:

1. generate an initial 'best study timetable':
    a. pseudo-randomly assign subjects to the available study periods;
    b. calculate the value of the Objective Equation;
2. for the number of Monte Carlo cycles specified in the parameters less one:
    a. copy the best study timetable to an experimental study timetable:
    b. for each available study period:
        i. select a pseudo-random value;
        ii. if that pseudo-random value is less than 3% of its range (i.e. 3% probability):
            1. change the subject to be studied to a pseudo-randomly selected subject
    c. calculate the value of the Objective Equation for the experimental study timetable.
    d. if the value of the Objective Equation for the experimental study timetable is less than that of the best study timetable:

i. copy the experimental study timetable to the best study timetable'

Study Plan must not attempt to assign a subject to a study period if an exam is scheduled to take place during that study period. In the above pseudo code, an 'available study period' is a period during which no exam is scheduled.

Study Plan must not attempt to assign a subject to a study period if the study period is after the last exam in that subject.

When all the cycles have been completed, the best study timetable is the most optimal study timetable that the algorithm can discover.

6 OUTPUT

When the search algorithm described in the previous section finishes, Study Plan must display the following information:

1. for each day in the best study timetable:
    a. date;
    b. for each study period in the best study timetable:
        i. if the study period is occupied by an exam:
            1. subject code of the exam;
            2. the character '*' to flag the exam;
            3. forecast result of the exam;
        ii. else:
            1. subject code of the subject to be studied during the period;
2. value of the objective equation for the best study timetable.