Homework # 5

Due: Monday Jul 31 , 2017 at 5 pm

Part I: Practice and Theory

1. Practice Problems: P4.2, P4.3, P4.7, P4.9, P4.16, P4.17 (not collected)

2. Chapter 4 Quiz (10 points). One attempt, 60 min time limit.

Part II : Programming

3. Coding Exercise (40 points).

Write a program that approximates the population growth of a species assuming the exponential growth model

$$P_t = (1 + r - E)\, P_{t-1}, \tag{1}$$

where P_t represents this year's population, P_{t-1} represents last year's population,

$$r = (birth\ \ rate - death\ \ rate) \tag{2}$$

is the growth rate constant, and E is an additional effect on the species due to environmental causes that has some inherent randomness and changes from year to year. This additional effect can be interpreted as adding or subtracting individuals from a population.

When $E = 0$, we say the model is deterministic and

$$P(t) = P_0(1 + r)^t, \tag{3}$$

where P_0 represents the initial population and $P(t)$ is the number of individuals in the population after t years.

Note that for the determinist growth model in equation (3), we can compute the population at any year $t = T$ by simply knowing P_0 and r. For the model that includes environmental influences in equation (1), we need to compute all the years from $t = 0$ to $t = (T - 1)$ before we can compute P_T.

Start your program by prompting the user to enter the initial population P_0, the birth rate, the death rate, and the amount of years T you are interested in studying the given population. Then, assuming the same trend will continue, write a function `growth_rate` that returns the growth rate constant r and a function `population` that estimates the population, choosing the right model depending on the value of E.

Using the deterministic model in equation (3), make your program find the estimate population $P(T)$ after T years. Implement the function `extinction` to determine if extinction is possible under given conditions.

Using the environmental model from equation (1), call the `population` function to output one estimate of P_T by computing the random environmental rate E for each year. Implement another function `extinction_probability` to compute the probability that the species will become extinct during T years under the random environmental model. You can do this by computing the population P_T under the environmental model 100 times and counting how many times the population becomes extinct.

Your program should not allow an initial population less than 2, negative population, or fractional population. Keep the random effect restricted such that $-1 \leq E \leq 1$. The final output should be a table comparing the population growth for the deterministic model and the environmental model, and the possibility of extinction in both cases. A sample output is shown in Figure 1.

```
Initial Population = 1900
Birth Rate = 0.3
Death Rate = 0.35
Years = 15


MODEL                   YEARS    POPULATION    EXTINCTION
DETERMINISTIC              15           880      POSSIBLE
ENVIRONMENTAL             15            15    PROB = 0.6
```

Figure 1: Hmw5 sample output