#### **Task 2. Evolution of a biological species. Differential equations**

The task consists of three questions:

1. A differential equation *x*'*=f*(*x*) is given. It is necessary determine its equilibrium states.
2. For the Malthus model *x*'=(*a*–*b*)*x*, *х*(0)=*х*0, it is necessary to choose all parameters for obtaining a specified effect and explain the system evolution. Attention: some effect can be impossible; it this case, it is necessary to explain the reason.
3. Some parameters of the Verhulst model *x*'*=*[(*аD*–*b*)–*аqx*(*t*)]*x*, *х*(0)=*х*0 are given. It is necessary to choose other parameters for obtaining a specified effect and explain the system evolution.

#### **Variants of the tasks**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **№** | **1. Equation** | **2. Malthus model**  (effect) | **3. Verhulst** **model** | |
| parameters | effect |
| 1 | *x*' *= x*2+*x–*2 | monotonic population growth until an equilibrium state | *a=*1, *D=*100, *х*0=10 | number of species decreases to an equilibrium position |
| 2 | *x*' *= –x*2*+x+*2 | unlimited population growth | *b=*10, *q=*5, *х*0=20 | population extinction |
| 3 | *x*' *= x*2*–*2*x–*3 | population extinction | *a=*2, *b=*20, *q=*3 | monotonous increase  in the number of species |
| 4 | *x*' *= x*2*+*2*x–*3 | monotonous population decline | *a=*5, *D=*20, *b=*50 | absence of population |
| 5 | *x*' *= x*2*–*3*x+*2 | population constancy | *a=*5, *D=*10, *q=*2 | monotonous decrease  in the number of species |
| 6 | *x*' *= x*2*+*3*x+*2 | monotonic decrease of the population until  the equilibrium position | *a=*3, *b=*10, *х*0=10 | number of species increases to an equilibrium position |
| 7 | *x*' *= x*2+*x–*6 | non-monotonous  population decline | *a=*2, *q=*2, *х*0=10 | monotonic decrease of the population until the equilibrium position |
| 8 | *x*' *= –x*2*+x+*6 | change in population size to  a positive equilibrium position | *D=*10, *b=*20, *q=*5 | population constancy |
| 9 | *x*' *= x*2+5*x+*6 | monotonous increase  in the number of species | *D=*5, *b=*30, *х*0=20 | monotonic increase of the population until the equilibrium position |
| 10 | *x*' *= x*2*–*5*x+*6 | monotonous decrease  in the number of species | *D=*8, *q=*1, *х*0=15 | monotonous population decline |
| 11 | *x*' *=–x*2*+*3*x+*4 | absence of population | *b=*10, *q=*2, *D=*8 | monotonic population growth  until an equilibrium state |