

1. Consider the modified logistic model

$$\frac{dN}{dt} = rN \left(1 - \frac{N^\alpha}{K}\right), \quad r > 0, K > 0, \alpha > 0.$$

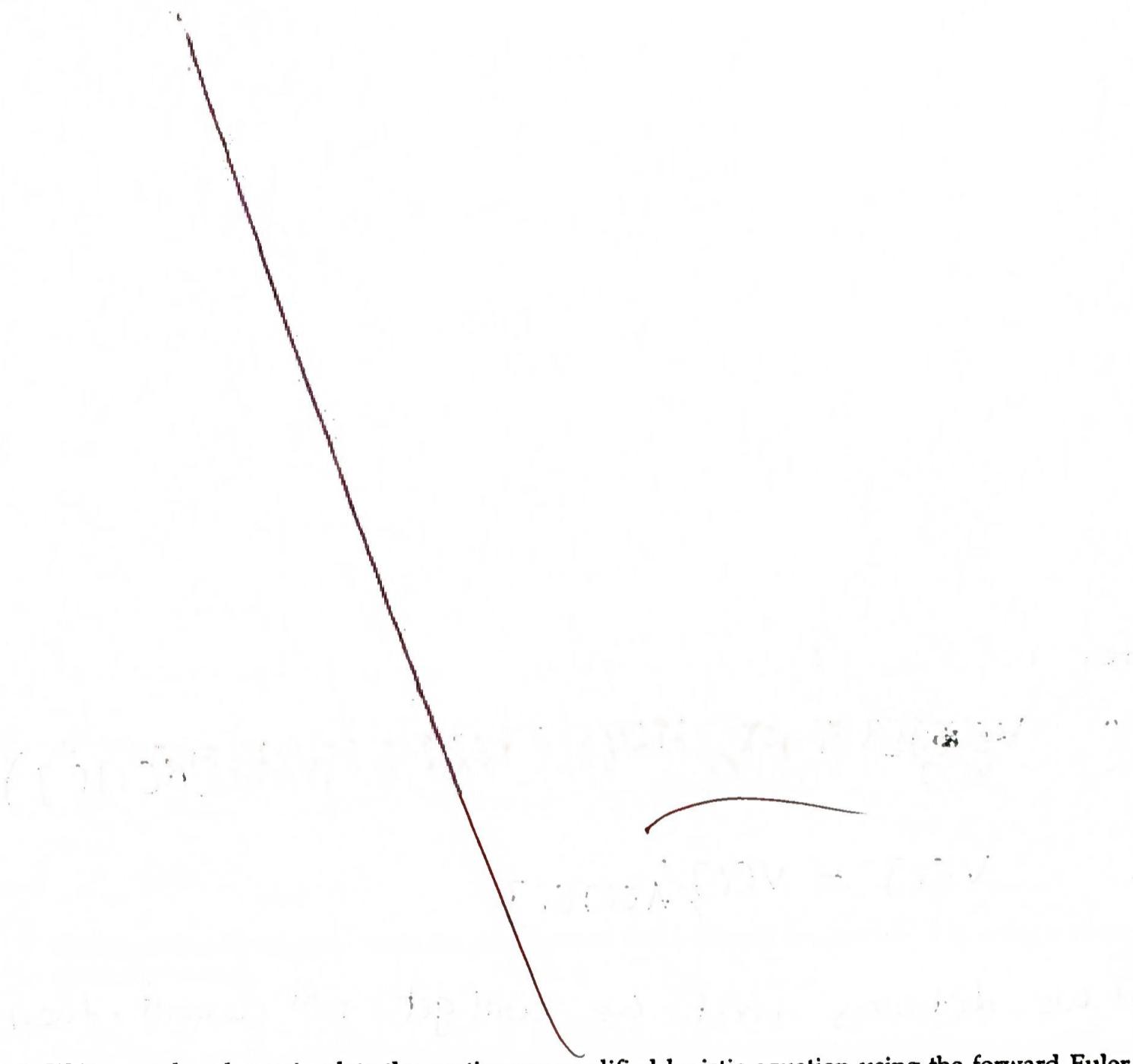
Find all fixed points of the system.

[2]

2. For a scalar ordinary differential equation  $\dot{x} = f(x)$ , linearise the system about a fixed point  $x^*$  and derive the condition for stability in terms of  $f'(x^*)$ .

[2]

3. Apply the result from part (2) to classify the fixed points of the modified logistic model obtained in part (1). [2]
4. Explain briefly why the population does not remain constant for an arbitrary nonzero initial condition  $N(0)$ , unless  $N(0)$  is an equilibrium point. [1]



5. Write pseudocode to simulate the continuous modified logistic equation using the forward Euler method. (No derivation of the Euler method is required.) [2]

6. Write an algorithm or pseudocode for solving the linear system

$$Ax = b,$$

when  $A$  is an upper-triangular matrix, assuming that a unique solution exists.

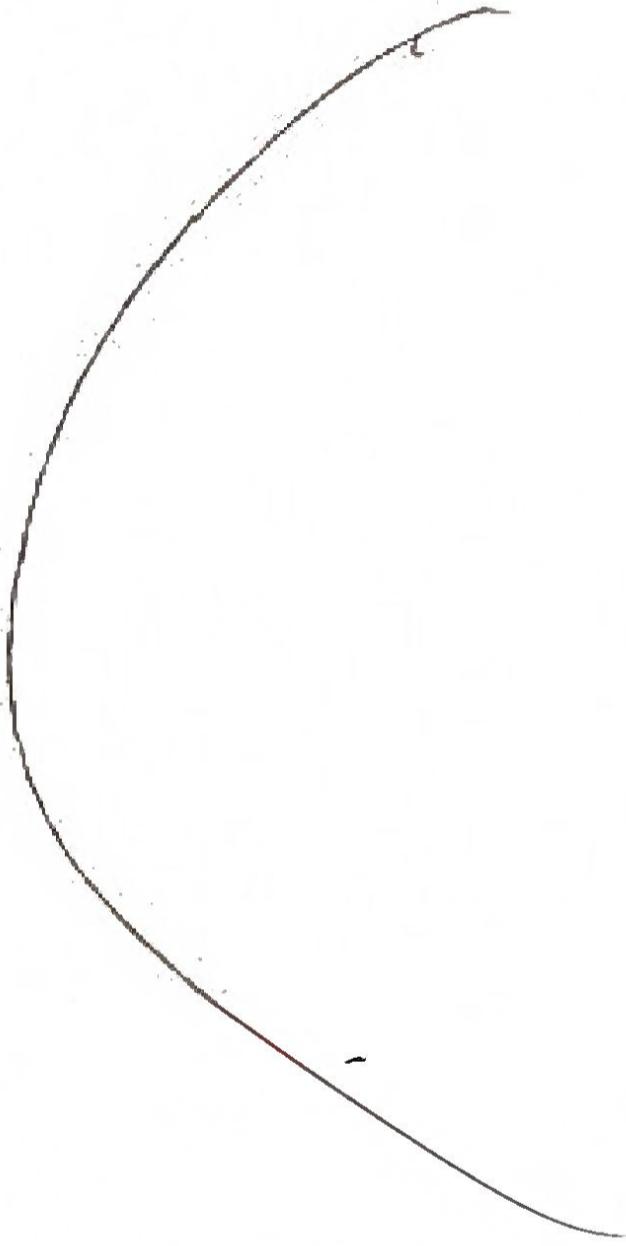
[2]

7. Consider the discrete map

$$x_{n+1} = 2.5x_n(1 - x_n), \quad n = 0, 1, 2, \dots,$$

with initial condition  $x_0 = 0.3$ . Explain what happens to  $x_n$  as  $n$  becomes very large.

[2]



8. Write pseudocode to approximate the derivative of  $f(x) = \sin x$  at the point  $x_0 = \frac{\pi}{4}$ , using a finite-difference method.

[2]

9. What type of linear transformation preserves the Euclidean norm in linear least-squares problem  
Prove your claim.