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# Existence and uniqueness of positive periodic solutions for a class of integral equations with mixed monotone nonlinear terms \*

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## Abstract

We study the existence and the uniqueness of positive periodic solutions for a class of integral equation of the form

$$\phi(x) = \int_{[x, x+\omega] \cap G} K(x, y)[f_1(y, \phi(y - \tau(y))) + f_2(y, \phi(y - \tau(y)))]dy, \quad x \in G,$$

where  $G$  is a closed subset of  $\mathbb{R}^N$  with periodic structure. Our analysis relies on the fixed point theory for mixed monotone operator in Banach space.

key words: periodic solution, fixed point theory, mixed monotone operator, existence and uniqueness

Mathematics Subject Classifications: 39A23

## 1 Introduction

We first introduce some notations that will be used in this paper. Let  $\mathbb{R}^N$  be the  $N$ -dimensional Euclidean space endowed with the componentwise ordering ' $\leq$ '. For any  $u, v \in \mathbb{R}^N$ , the 'interval'  $[u, v]$  denotes the set  $\{x \in \mathbb{R}^N \mid u \leq x \leq v\}$ . Let  $\omega = (\omega_1, \dots, \omega_N) \in \mathbb{R}^N$  with positive components and  $e^{(1)} = (1, 0, \dots, 0), \dots, e^{(N)} = (0, \dots, 0, 1)$  be the standard orthonormal vectors of  $\mathbb{R}^N$ . It is assumed that  $G$  is a closed subset of  $\mathbb{R}^N$  which has the following 'periodic' structure: for each  $x \in G$ ,

$$x + \omega_i e^{(i)} \in G, \quad i = 1, 2, \dots, N,$$

and for each pair  $y, z \in G$ ,

$$\mu([y, y + \omega] \cap G) = \mu([z, z + \omega] \cap G) > 0.$$

For the sake of convenience, we set

$$G(x) = [x, x + \omega] \cap G.$$

It is well-known that the nonlinear Hammerstein integral equation of the form

$$\phi(x) = \int_{\Omega} B(x, y)f(y, \phi(y))dy$$

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