Green's Function and Positive Periodic Solution For Third-order Nonlinear Differential Equations

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In the study of higher order differential equation, the naive idea to translate the equation into a first order system of differential equations by defining $x_1 = x$, $x_2 = x'$, $x_3 = x''$, ..., which works well for showing existence of periodic solutions, does not obviously lead to existence proofs for positive periodic solutions, since the condition $x = x_1 \geq 0$ of positivity for the higher order equation is different from the natural positivity condition $(x_1, x_2, \dots) \geq 0$ for the corresponding system. An approach which is frequently used is to transform the higher-order equation into a corresponding integral equation and to establish the existence of positive periodic solutions based on a fixed point theorem in cones. Following this path one needs an explicit representation of the Green's function which is rather intricate to compute, see [1, 2] etc. In this paper, we provide the Green's function and their properties for some third-order differential equations, and based on these results we obtain the existence of periodic solution of corresponding nonlinear third-order differential equation.

[1] R. Agarwal, *Boundary value problems for higher order differential equations*, World Scientific Publishing Co., 1986.

[2] D. R. Anderson, *Green's function for a third-order generalized right focal problem*, J. Math. Anal. Appl, **288** (2003), 1-14.