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Multiple solutions of problems with nonlinear first order differential operators

We present results establishing the existence of solutions to first order differential equations with nonlinear differential operators of the following form:

$$\phi(u(t)))' = f(t, u(t)) \quad \text{a.e. } t \in [0, T],$$

with periodic boundary value or the initial value conditions. Here ϕ is is an increasing nonlinear homeomorphism. Multiplicity results are also presented. Our results rely on the notion of upper and lower solutions and on the fixed point index theory.