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**Perturbation Methods I
Singular Perturbations, Lindstedt's Technique**

SET IV

1. Consider the problem

$$\ddot{u} + u + \varepsilon u^2 = 0; \text{ with } u(0) = a, \text{ and } \dot{u}(0) = 0.$$

Determine a three-term uniformly valid solution using the Lindstedt approach.

2. Determine a two-term uniformly valid solution for small amplitudes of the equation that governs the motion of a pendulum of length L subject to a gravitational field of intensity g :

$$\ddot{\theta} + \frac{g}{L} \sin \theta = 0; \text{ with } \theta(0) = \theta_0, \text{ and } \dot{\theta}(0) = 0.$$

Nondimensionalize the angle with θ_0 and assume θ_0 is small, but not so small that a one-term Taylor series expansion for $\sin \theta$ would be sufficient.