Bu kabi testlar talabalar nazariy olgan bilimlarini mustahkamlashda amaliy (seminar) mashg'ulotlar davomida yana bir bor takrorlashga va shu bilan birga uni mustahkamlash vositasi bo'lib xizmat qiladi [2].

Amaliy mashg'ulotda yakunida talabalarga yadro modellariga klaster tuzish topshiriladi.

Talabalar uyda bu klaster topshirig'ini bajarib kelishadi va keying amaliy mashg'ulotning o'tilgan mavzuni takrorlash qismida muhokama qiladilar. Bunda, talabalar o'zlarini klasteridagi to'g'ri va noto'g'ri bog'lamlarini bilib oladilar [3].

Huddi shu kabi boshqa amaliy mashg'ulotlarni ham yangi zamonaviy pedagogik texnologiyalar yordamida tashkil qilish imkonini yaratadi.

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EXTENSION AND APPLICATION OF NEWTON'S METHOD IN NONLINEAR OSCILLATION THEORY

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Annotation. In the field of nonlinear vibration theory, Newton's method serves as a powerful tool for approximating the solutions of differential equations governing the dynamics of nonlinear vibrating systems. The extension of Newton's method in the form of nonlinear vibration theory involves the adaptation of classical calculus to efficiently solve the nonlinear differential equations that govern the behavior of vibrating systems. Newton's method makes it possible to solve nonlinear vibration equations that often occur in various physical phenomena, including mechanical vibrations and electrical circuits. By improving the initial theoretical calculations, Newton's method allows accurate approximation of solutions that provide insight into the characteristics of nonlinear vibration systems. Newton's method offers computational efficiency and accuracy compared to traditional analytical methods in solving nonlinear vibration equations, especially for complex nonlinear systems where this method is reflected in certain solutions.

Keywords: Newton's method, nonlinear oscillations, dynamical systems, differential equations, numerical methods, iterative algorithms, convergence analysis, stability analysis, limit cycles, nonlinear dynamics, computational physics, oscillatory systems, nonlinear equations, Newton-Raphson method.

Introduction: We all know that because the nonlinear oscillation is very important in theory and application, it is a main subject studied by mathematicians and mechanicians. The analytic method in the study of nonlinear oscillation is most important.

Because derivative systems of quasi-linear systems are the simplest linear ordinary differential equations with constant coefficients and the small parameters appear in the equations, the homotopy invariants between the original systems and derivative system was quite easily set up. Therefore, the theory and the method for studying the periodic solution to quasi-linear systems have already been obtained, such as asymptotic method, small parameter method and method of multiple scales$[2;-4]$. However, the study of general strong nonlinear systems is very difficult. The main difficulty is that in the general case the concept of the derivative systems is not clear. Even if the small parameters exist in the control equations, the derivative systems also show strong nonlinearity. Therefore, it is very difficult to find out the integration of the derivative systems. In spite of this, scholars of many countries have done a lot in the strong nonlinear oscillation. So far, the methods in the study of quasi-linear systems have been extended to the study of strong nonlinear oscillation, references [5;-6] apply asymptotic method to investigate quasiconservative system and in reference [7] Burton discussed the similar problem by using time transfomation method. But at present it is evident to lack the unanimous effective analytic method for studying strong nonlinear nonautonomous systems, especially the case of large amplitude excitation. Although in some cases we can obtain the approximate periodic solutions of strong nonlinear systems by using the. approximate methods as direct variational method and Galerkin method and so on, to raise the calculation accuracy makes unknown numbers increase, sothat solving the transcendental equations is very difficult, and at the same time it is not probable to obtain the asymptotic analytic solutions with explicit occurrence. Therefore, the application of these direct approximate methods is restricted. Besides, Liapnov system method developed by I.G. Malkin is only suitable to small amplitude oscillation.

On the other hand, we note that Newton's method used long ago to solve the algebraic and transcendental equations has the characters of making the nonlinear problems transformed into the linear problems, alternating programs being simpler with fast speed of convergence.

The eminent former Soviet scholar L.V.Contolovich first successfully applied Newton's method to study abstract operators in the functional, space, and at the same time he suggested simplified Newton's method and studied the existence of the periodic solution for the second order nonlinear system about some class. But his proof can not give the analytic method to calculate the periodic solutions.

We consider

$$\ddot{x}(t) = \phi(t) \cdot x(t) + \psi(t)\dot{x}(t) + f(t) \qquad (1)$$

and assume that $\phi(t)$ $\Psi(t)$ and $f(t)$ are all continuous periodic functions of periodic $2\pi/\omega$ so, they can be expanded into Fourier series of the complex form as follows:

$$\phi(t) = \sum_{n=-\infty}^{\infty} \xi_n \cdot exp[in\omega t] \qquad (2)$$

$$\psi(t) = \sum_{n=-\infty}^{\infty} \zeta_n \cdot exp[in\omega t] \qquad (3)$$

$$f(t) = \sum_{n=-\infty}^{\infty} a_n \cdot exp[in\omega t] \qquad (4)$$

We let

$$x(t) = \sum_{n=-\infty}^{\infty} a_n \cdot exp[in\omega t] \tag{5}$$

Putting (2 -4) and (5) into (1) and equating the coefficients of the same harmonics on both sides yields

$$\begin{cases} a_0 + \sum_{r=-\infty}^{\infty}(\xi_{-r} + \delta(r) + ir\omega\zeta_{-r})a_r = -a_0 \\ a_n + \frac{1}{n^2\omega^2} \cdot \sum_{r=-\infty}^{\infty}(\xi_{n-r} + \delta(r) + ir\omega\zeta_{n-r})a_r = -\frac{a_n}{n^2\omega^2} \end{cases} \quad \text{(6a) and (6b)}$$

$$(n = \pm 1, \quad \pm 2, \ \ldots .)$$

where

$$\delta(r) = \begin{cases} -1, & r = 0 \\ 0, & r \neq 0 \end{cases} \tag{7}$$

$$M = \{\sum_{n=0}^{\infty} |\xi_n|^2\}^{\frac{1}{2}} \tag{8}$$

$$Q = \{\sum_{n=0}^{\infty} |\zeta_n|^2\}^{\frac{1}{2}} \tag{9}$$

$$R = \{\sum_{n=0}^{\infty} |a_n|^2\}^{\frac{1}{2}} \tag{10}$$

In addition, we also assume $\psi(t)$ is continuous, so on the strength ofdifferentiable theorem term by term to Fourier series in reference [9] we have

$$N = \{\sum_{n=\infty}^{\infty} n^2|\zeta_n|^2\}^{\frac{1}{2}} < +\infty \tag{11}$$

and let the integer

$$r^*(n) = \min(\{r \downarrow r^2 < 2(n-r)^2\} \tag{12}$$

then

$$r^*(n) = 4n \tag{13}$$

It clearly visible that when $\forall\, r > r^*(n)$ we $r^2 < 2(n-r)^2$ So considering (8 - 9), (11 - 12) and (13), we have

$$\sum_{|n|=1}^{\infty}\sum_{r=-\infty}^{\infty}\left|\frac{\xi_{n-r}+ir\omega\zeta_{n-r}}{n^4}\right|^2 \le \sum_{|n|=1}^{\infty}\sum_{r=-\infty}^{\infty}\left|\frac{|\xi_{n-r}|^2+r^2\omega^2|\zeta_{n-r}|^2}{n^4}\right|^2$$

$$\le \sum_{|n|=1}^{\infty}\sum_{r=-\infty}^{\infty}\frac{|\xi_{n-r}|^2}{n^4}$$

$$+\omega^2\sum_{|n|=1}^{\infty}\sum_{|r|<r^*(n)}\frac{[r^*(n)]^2\,|\xi_{n-r}|^2}{n^4}$$

$$+2\omega^2\sum_{|n|=1}^{\infty}\sum_{|r|>r^*(n)}\frac{(n-r)^2\,|\xi_{n-r}|^2}{n^4}$$

$$\le 2(M^2+2\omega^2N^2)\sum_{n=1}^{\infty}\frac{1}{n^4}+32\omega^2Q^2\sum_{n=1}^{\infty}\frac{1}{n^2}<+\infty$$

Therefore

$$I_1=\sum_{r=-\infty}^{\infty}|\xi_{-r}+\delta(r)+ir\omega\zeta_{-r}|^2+\sum_{|n|=1}^{\infty}\sum_{r=-\infty}^{\infty}\frac{|\xi_{-r}+\delta(r)+ir\omega\zeta_{-r}|^2}{n^4}<+\infty \quad (14)$$

$$\sum_{|n|=1}^{\infty}\frac{|a_n|^2}{n^2}<2R^2<+\infty \quad (15)$$

so

$$I_2=|a_0|^2+\sum_{|n|=1}^{\infty}\frac{|a_n|^2}{n^2\omega^2}<+\infty \quad (16)$$

let

$$\eta_1=\left\{\sum_{|n|>m+1}^{\infty}\sum_{r=-\infty}^{\infty}\left|\frac{\xi_{n-r}+ir\omega\zeta_{n-r}}{n^2\omega^2}\right|\right\}^{\frac{1}{2}} \quad (17)$$

It is clearly visible that

$$\lim_{m\to\infty}\eta_1=0 \quad (18)$$

and let

$$\eta_2=\left\{\sum_{|n|>m+1}^{\infty}\frac{|a_n|^2}{n^2\omega^2}\Big/\sum_{|n|=1}^{\infty}\frac{|a_n|^2}{n^2\omega^2}\right\}^{\frac{1}{2}} \quad (19)$$

It is clearly visible that

$$\lim_{m\to\infty}\eta_2=0 \quad (20)$$

We can change the form of equations (6) into still simpler one as follows

$$Ka = (I + H)a = \alpha \tag{21}$$

The equations

$$K'a' = (I' + H')a' = \alpha' \tag{22}$$

Are called the cut equations of (6), which can take the place of (6) approximately, where I' is $(2m+1)(2m+1)$ order unit matrix, $a' = [a_n]^T_{n=0,\pm1,\pm2\ldots\pm m}$; H' is $(2m+1)(2m+1)$ order matrix located at the upper left side in H. The operator ϕ represents the following transformation

$$x' = \phi x$$

Where $= [x_f]^T_{i=0,\pm1,\pm2,\ldots.}$. It is clearly visible that

$$\|\phi K\| \le 1 + \|\phi H\| \le 1 + \sum_{|n|=1}^{\infty} \sum_{r=-\infty}^{\infty} \left|\frac{\xi_{n-r} + ir\omega\zeta_{n-r}}{n^4}\right|^2 +$$

$$+ \sum_{r=-\infty}^{\infty} |\xi_{-r} + \delta(r) + ir\omega\zeta_{-r}|^2 < +\infty \tag{23}$$

and

$$\|K'^{-1}\| = \max_{f=0,\pm1,\pm2\ldots\pm m} \frac{1}{1 + \sqrt{|\lambda_f|}} \tag{24}$$

where $\lambda_f (j = 0, \pm1, \ldots, \pm m)$ are the eigenvalues of the matrix, $H'^* \cdot H'$. H'^* is Hermite adjoint matrix of H'. So from Ref. [8] we know that if the following inequalite is satisfied

$$T = \eta_1 \|K'^{-1}\| \cdot \|\phi K\| < 1 \tag{25}$$

Then when, $m \to \infty$, the solution of (22) must converge to the solution of (21). From formula (24), it is clear that norms $\|K'^{-1}\|$ for all m, which are arbitrary integers, must have the upper boundary. By this and considering (23) and (28), we know when m is sufficiently large integer, formula (25) can always be established. Therefore if the cut equations (22) have the solution, then when, $m \to \infty$, the solution of (22) must converge to the solution of (21).

Now we will prove that periodic solution of (1) obtained by means of the above method is absolute uniform convergence. For the sake of our purpose, substituting (5) into (1) and considering (8 – 9) and (10), we obtain

$$n^2\omega^2|a_n| \le \mu(1+|n|)|a_n| + R \qquad (26)$$

where

$$\mu = max\{M, \omega Q\} \qquad (27)$$

When $|a_n|$ is sufficiently large, so that $|a_n| > s$, where the integer s satisfies the following inequality

$$s > \frac{1}{2}\left\{\frac{\mu}{\omega^2} + \sqrt{\frac{\mu^2}{\omega^4} + \frac{4\mu}{\omega^2}}\right\} \qquad (28)$$

so we have

$$|a_n| \le \frac{R}{n^2\omega^2 - \mu(1+|n|)} \qquad (n = \pm 1, \pm 2, \ldots) \qquad (29)$$

Therefore, from (5) and (29) we obtain

It is clearly visible that the right-hand side of (30) is a bounded positive value, from which we can arrive at the following conclusion.

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THE POINCARE METHOD IN TEACHING THE THEORY OF NONLINEAR VIBRATIONS

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Annotations. In the realm of continuum mechanics, Poincaré's theory provides a framework for understanding the nonlinear propagation of waves in diverse media, such as nonlinear acoustic waves, solitary waves (solitons), and shock waves. By characterizing the stability, bifurcations, and interactions of nonlinear waves, researchers can elucidate the underlying mechanisms governing wave phenomena