4-2. Using the general procedure explained in Section 4.3, the phase diagram is constructed as follows:

4-3. The potential \( U(x) = -\left(\frac{\lambda}{3x}\right)^3 \) has the form shown in (a) below. The corresponding phase diagram is given in (b):
4-8. For \( x > 0 \), the equation of motion is

\[ m \ddot{x} = -F_0 \]  

(1)

If the initial conditions are \( x(0) = A, \dot{x}(0) = 0 \), the solution is

\[ x(t) = A - \frac{F_0}{2m} t^2 \]  

(2)

For the phase path we need \( \dot{x} = x(x) \), so we calculate

\[ x(x) = \pm \sqrt{\frac{2F_0}{m}} (A - x) \]  

(3)

Thus, the phase path is a parabola with a vertex on the \( x \)-axis at \( x = A \) and symmetrical about both axes as shown on the left.

Because of the symmetry, the period \( \tau \) is equal to 4 times the time required to move from \( x = A \) to \( x = 0 \) (see diagram). Therefore, from (2) we have

\[ \tau = 4 \sqrt{\frac{2mA}{F_0}} \]  

(4)

4-9. The proposed force derives from a potential of the form

\[ U(x) = \begin{cases} \frac{1}{2} kx^2 & |x| < a \\ \frac{1}{2} (k+\delta)x^2 - Sx & |x| > a \end{cases} \]

(1)

which is plotted in (a) below.

For small deviations from the equilibrium position \( (x = 0) \), the motion is just that of a harmonic oscillator.

For energies \( E < E_1 \), the particle cannot reach regions with \( x < -a \), but it can reach regions \( x > a \) if \( E > E_1 \). For \( E_2 < E < E_1 \), the possibility exists that the particle can be trapped near \( x = a \).

A phase diagram for the system is shown in (b) below.