Part I
Conservative Systems

In this part, we introduce the LPT as fundamental notion in non-stationary resonance dynamics starting from the simplest conservative quasi-linear system of two weakly coupled identical oscillators (Sect. 1.1). The role of LPTs in the resonance energy exchange and transition to energy localization at initially excited oscillator is demonstrated. Then (Sect. 1.2), we define the LPTs in a more general conservative two-degrees-of-freedom (2DOF) system assuming a small frequency detuning between the oscillators. We suggest a thorough dynamical analysis, which helps us to highlight a similarity between classical and quantum systems and to find the sets of parameters corresponding to different types of dynamical behavior of the coupled systems. Besides, the suggested analysis underlies further study of coupled oscillators with slowly varying parameters in the Part II.

We show further (Sects. 2.1 and 2.2) that the LPT concept remains very productive even in the case when equations of motion cannot be linearized. Two such systems are considered which are similar to a weightless unstretched preliminarily string with two uniformly situated point-like masses. In the first model (Sect. 2.1), the motion of the particles occurs in the transversal (to the string) direction only (scalar case). In Sect. 2.2.4, this restriction is removed.

Section 3.1 is devoted to more complicated case of three weakly coupled nonlinear oscillators. We analyze a change in the types of fundamental non-stationary resonance processes described by LPTs with weakening the inter-particle coupling.

In the three following Sects. 4.1–4.3, it is shown how the LPT concept works in the case of finite multi-particle system. We consider subsequently Fermi–Pasta–Ulam (FPU), Klein–Gordon (KG), and dimer oscillatory chains and show that the LPT concept successfully works in multi-particle system if to introduce certain clusters of coupled particles (coherence domains) that allow, in particular, to generalize the beat notion on the systems with many degrees of freedom.

Finally, Sects. 5.1–5.3 are devoted to energy exchange between two oscillatory chains.