Note: The actual value of $H(p,q)$ is constant $\forall t \geq 0$.
So $H(t) - H(0) = 0$ (Actual value)
Also the actual values of p, q (found using ODE45) show a symmetric behaviour

Observations:

Forward Euler: For $h = 2.3684$ and $h = 2.3685$ the graph $H(t) - H(t_0)$ vs t is almost same. So no abnormal behaviour there. The graph for $h=2$ is more accurate (closer to 0) with max value being around 0.5. After that error almost remains same. But the Hamiltonian in this case has a lot of error and there is no symmetry in the error (Actual values of p, q are found to be symmetric).
This method is not very good for the given equations

Leapfrog: For $h=2$ the value $H(t) - H(t_0)$ is very close to 0. It is also showing a symmetric behaviour (which should be there). The error is of the order 10^{-5}. Even for $h = 2.3684$ and $h = 2.3685$ the symmetric behaviour is shown. But in case of $h = 2.3684$ there is a sudden spike in the value (goes to approx 2×10^{-3}). This sudden increase in the error is because of resonance instability. For $h = 2.3685$ there is no drastic instability. This is a good method for the given equations.

Symplectic Euler: It's behaviour is very similar to leapfrog. It is also showing resonance instability. But in this case even for h= 2.3685 (along with h=2.3684) we observe resonance instability (unlike leapfrog). This is a good method for the given equations.