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**Hint to Exercise 2.4.1**

$\Xi_e$  is periodic under very general conditions (cf. [50]). Indeed, from Eqn. (2.38), we have

$$\Xi_k \Big|_0^{2\pi} = \frac{\partial}{\partial J_k} \oint \hat{p}_1(q_1, J) dq_1 = \frac{\partial J_1}{\partial J_k} = 0 \quad (k \geq 2).$$