S4 Force on a Flapping Wing in Potential Flow

By applying FPM to the Euler equation (S11a) we obtain the net force on the wing due to potential flow to be

\[ F_b = -\rho \int_{B+\Sigma} \hat{n} \cdot \frac{d\hat{U}_B}{dt} \Phi^{(i)} dS - \rho \int_B \frac{1}{2} U_B^2 n_i dS + \rho \int_{V_f} \nabla \cdot \left( \frac{1}{2} U_B^2 \right) \Phi^{(i)} dV \]

For a wing undergoing periodic motion in an inviscid potential flow, since the flow field at the beginning and end of the flapping cycle is exactly the same, this necessarily implies that the wing does not transfer any net momentum to the flow over one wing flap. From this it follows that the cycle-averaged force associated with potential flow for a flapping wing, which is given by the above equation, is necessarily zero.