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Pitch and heave dynamics of an elastically-mounted cyber-physical hydrofoil[1] YUNXING SU, KYOHEI ONOUE, MICHAEL MILLER, KENNETH BREUER, Brown University — The energy harvesting performance of an elastically-mounted hydrofoil (chord, c, span, s) subject to a prescribed pitching motion is studied using a cyber-physical force-feedback control system. We vary the mass, m, the frequency of the pitching motion, ω, the parameters of the elastic support (stiffness, k and damping, b) and the Reynolds number, Re. The extracted energy is obtained from measured heave force and velocity, $F\dot{y}$. The ratio between the pitching frequency and the natural frequency of the system, $\omega/\sqrt{k/m}$, and the damping coefficient, $b/(0.5\rho Usc)$, are found to play a major role. In particular, the maximum power output is achieved at a frequency ratio of 1, which corresponds to an optimal phase difference of 90° between the driven pitch and passive heave motions. At the resonance condition, the damping coefficient defines the heaving amplitude, H, and thus the width of the wake and the Strouhal number, $St = fH/U$. The power coefficient, $C_p =< F\dot{y}/(0.5\rho U^3 sc) >$, reaches a maximum of 0.65 at a damping coefficient around 1.5, regardless of the Reynolds number (Re = 20,000 - 55,000). The contribution of the pitch component to power extraction is found to be small ($< 10\%$ of the heave component).

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