5.3.4 Force-velocity relation and stall force

The effect of an external force or load on the efficiency of the swimmer can be easily studied within the linear theory of Stokes hydrodynamics. When the swimmer is under the effect of an applied external force F, Eq. (5.25) should be changed as

$$F_1 + F_2 + F_3 = F. \tag{5.36}$$

Following through the calculations of Sec. 5.3.1 above, we find that the following changes take place in Eqs. (5.23a), (5.23b), (5.23c), and (5.24):

$$v_1 \mapsto v_1 - \frac{F}{4\pi\mu L_1}, \tag{5.37}$$

$$v_2 \mapsto v_2 - \frac{F}{6\pi\mu a_2}, \tag{5.38}$$

$$v_3 \mapsto v_3 - \frac{F}{4\pi\mu L_2}, \tag{5.39}$$

$$V \mapsto V - \frac{1}{3}\left(\frac{1}{6\pi\mu a_2} + \frac{1}{4\pi\mu L_1} + \frac{1}{4\pi\mu L_2}\right) F. \tag{5.40}$$