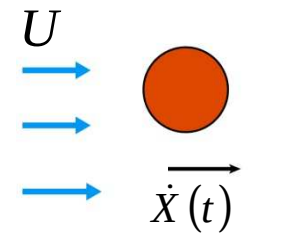
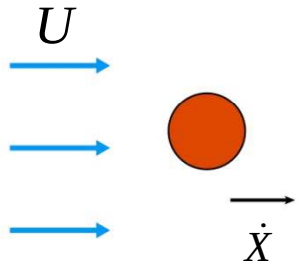
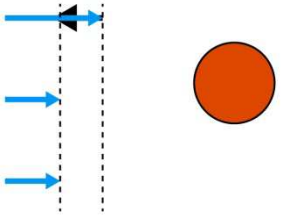
A CYLINDER MOVING ALONG A FLOW





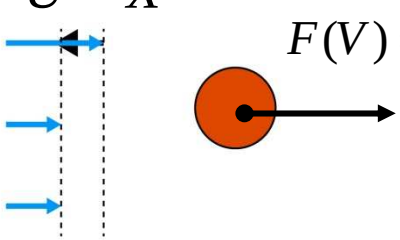
$U_R^2 >> D$

$V = U - \dot{X}$



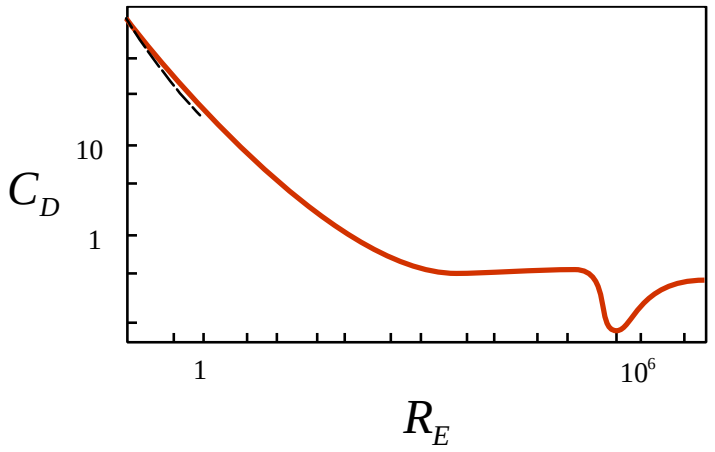
DRAG ON THE CYLINDER

$$V = U - \dot{X}$$



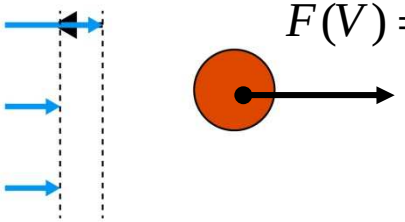
$$F(V) = \frac{1}{2}\rho V^2 L\, C_D(R_E)$$

$$R_E = \frac{\rho V L}{\mu}$$



DRAG ON THE CYLINDER

$$V = U - \dot{X}$$



$$F(V) = \frac{1}{2}\rho V^2 L\, C_D(R_E)$$

$$R_E = \frac{\rho V L}{\mu}$$

$$F(V) = F(U - \dot{X}) \approx F(U) + \dot{X}\frac{\partial F}{\partial \dot{X}} + \ldots$$

$$\frac{\partial F}{\partial \dot{X}} = \frac{\partial}{\partial \dot{X}}\left[\frac{1}{2}\rho V^2 L\, C_D\left(R_E\right)\right]$$

$$= \frac{\partial}{\partial \dot{X}}\left[\frac{1}{2}\rho (U - \dot{X})^2 L\, C_D\left(\frac{\rho (U - \dot{X}) L}{\mu}\right)\right]$$

$$\approx -\rho U L\left[C_D + \frac{1}{2}R_E\frac{\partial C_D}{\partial R_E}\right]$$

DRAG GALLOPING

$$F(V) \approx F(U) - \rho U L \dot{X} \left[C_D + \frac{1}{2} R_E \frac{\partial C_D}{\partial R_E} \right]$$

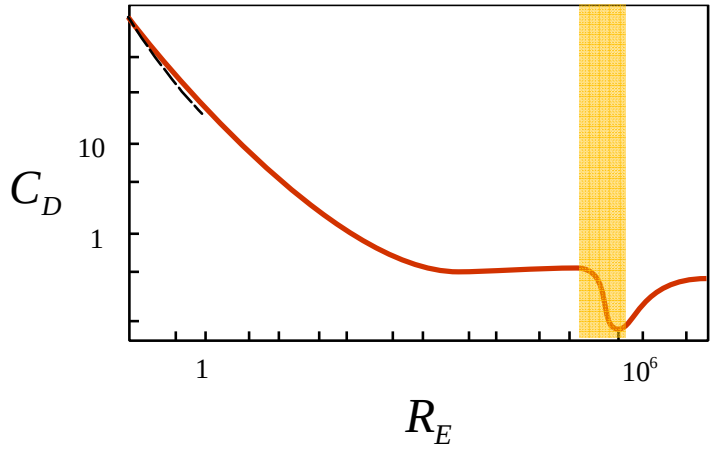
$$C_D + \frac{1}{2} R_E \frac{\partial C_D}{\partial R_E} > 0$$

Damping effect

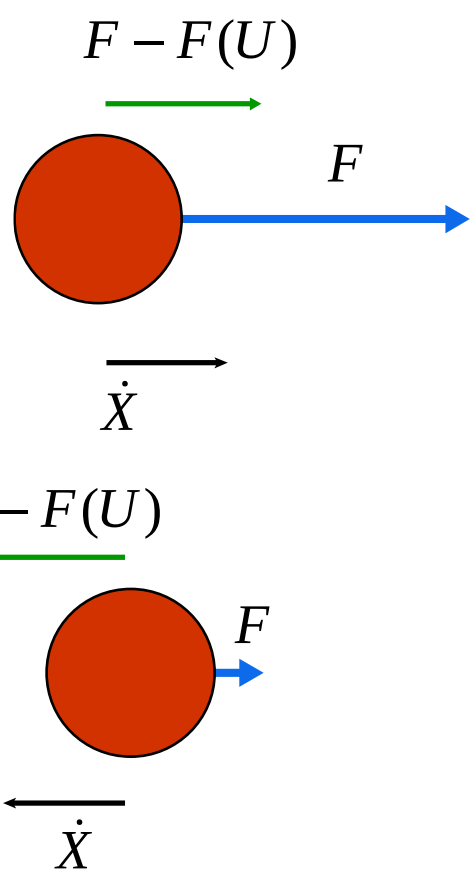
$$C_D + \frac{1}{2} R_E \frac{\partial C_D}{\partial R_E} < 0$$

Dynamic instabilitity

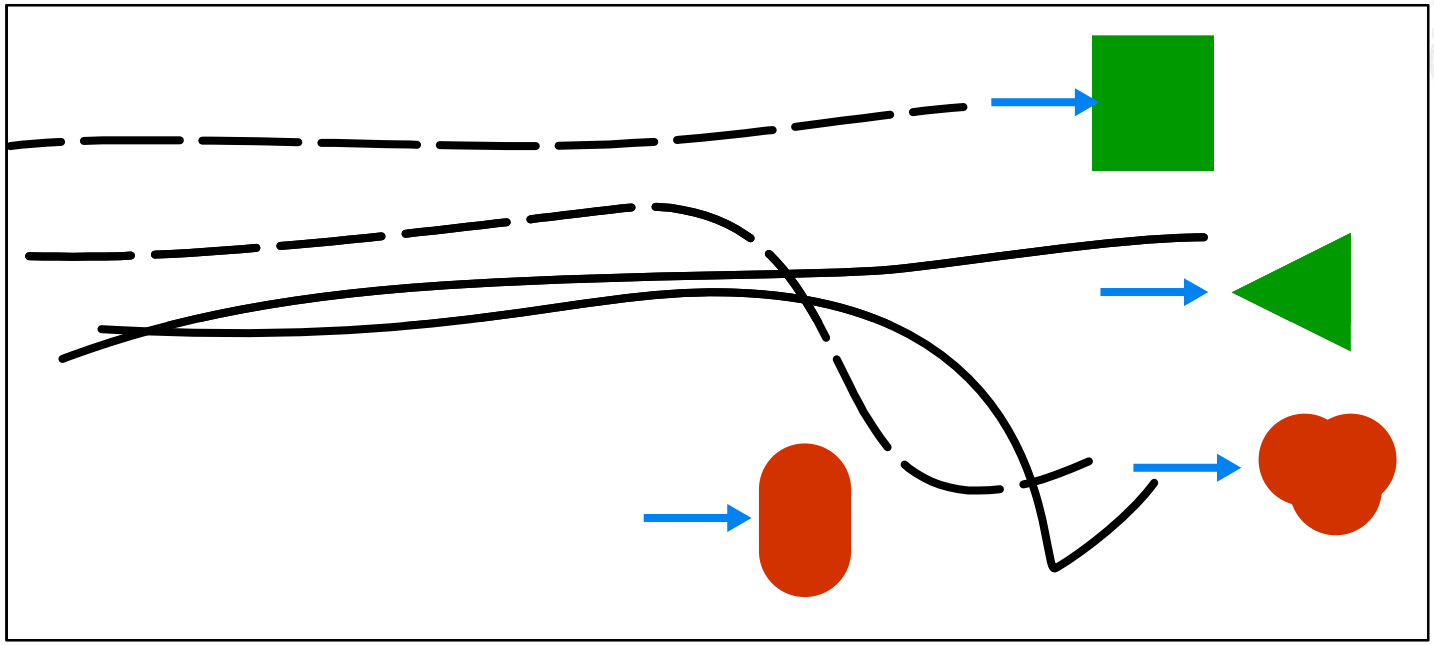
Drag Galloping



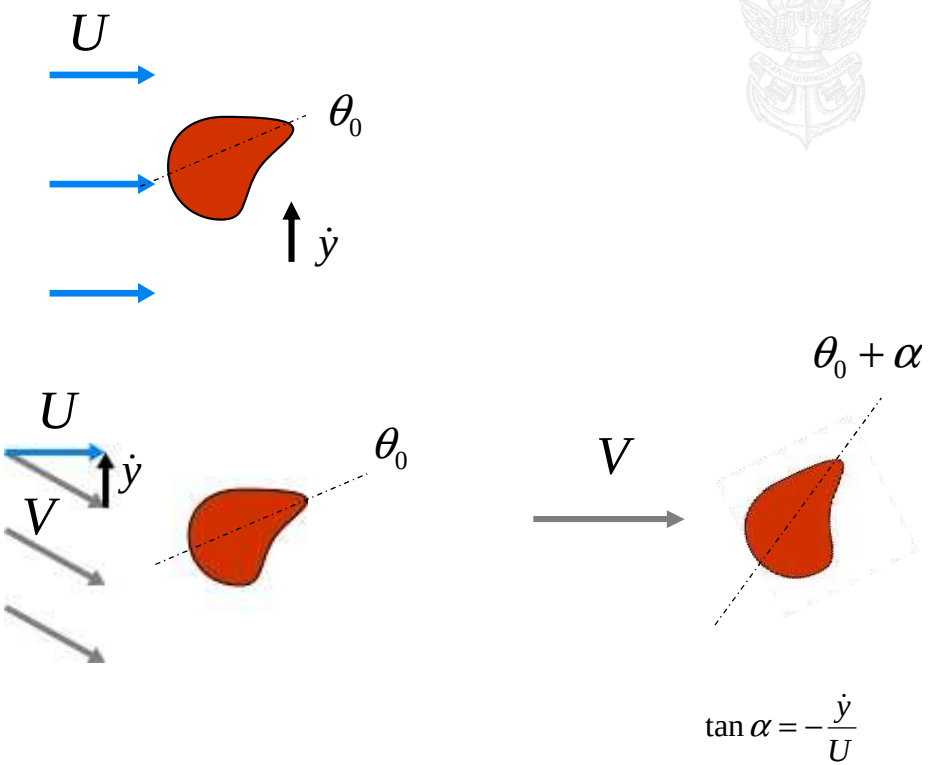
DRAG GALLOPING



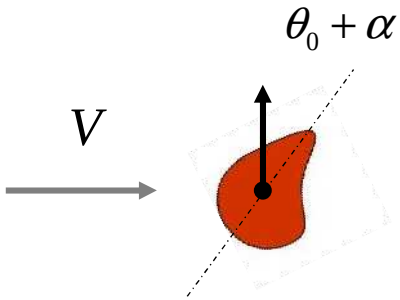
DRAG GALLOPING



A BLUFF BODY MOVING TRANSVERSELY TO THE FLOW



A BLUFF BODY MOVING TRANSVERSELY TO THE FLOW



$$\tan\alpha = -\frac{\dot{y}}{U}$$

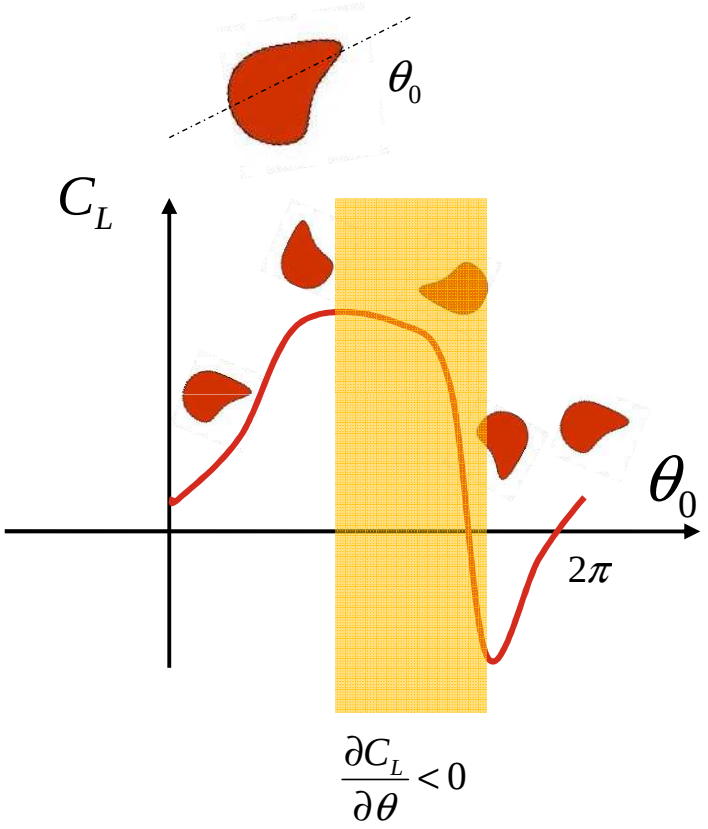
$$F_{FS} = \frac{1}{2}\rho U^2 L C_L(\theta_0 + \alpha)$$

$$= \frac{1}{2}\rho U^2 L C_L(\theta_0) + \frac{1}{2}\rho U^2 L\left(\frac{\partial C_L}{\partial \theta}\right)_{\theta_0}\alpha + \ldots$$

$$= F_{FS}{}^0 - \frac{1}{2}\rho U L\left(\frac{\partial C_L}{\partial \theta}\right)_{\theta_0}\dot{y} + \ldots$$

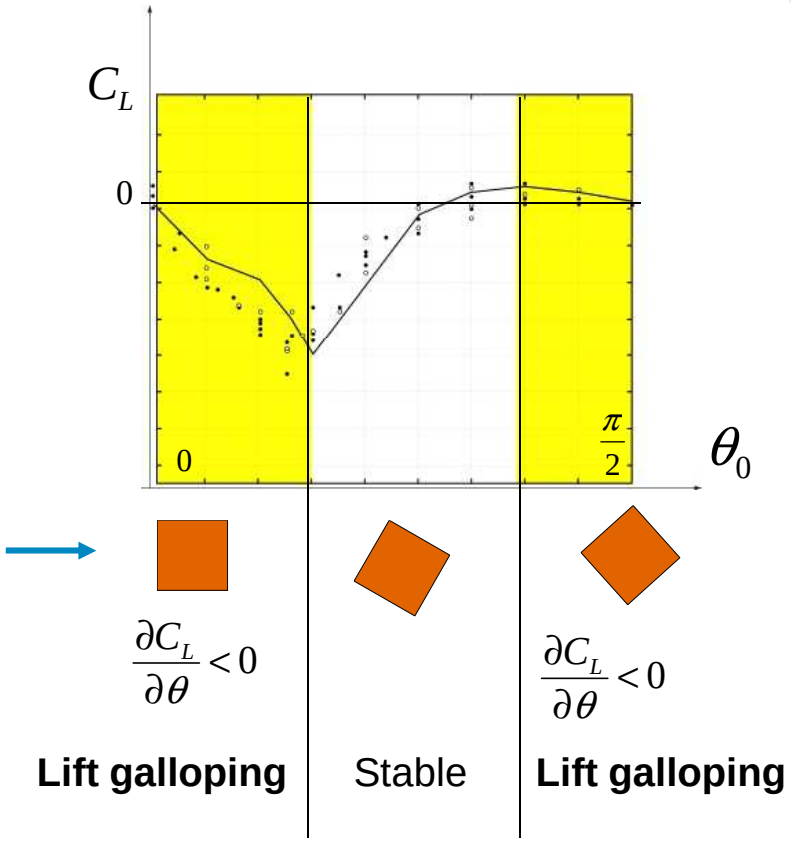
Flow-induced damping

LIFT GALLOPING

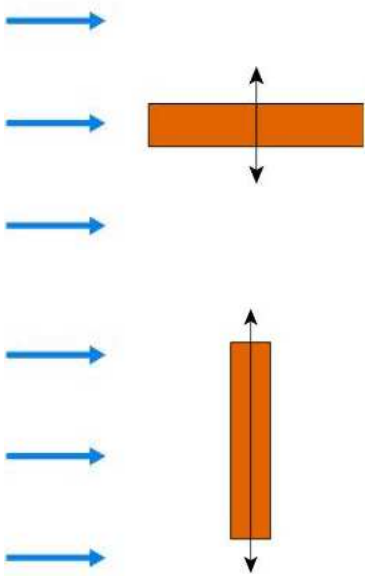


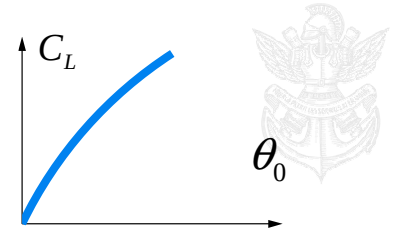
Lift galloping

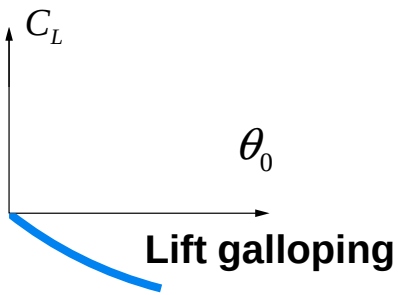
LIFT GALLOPING OF A SQUARE SECTION



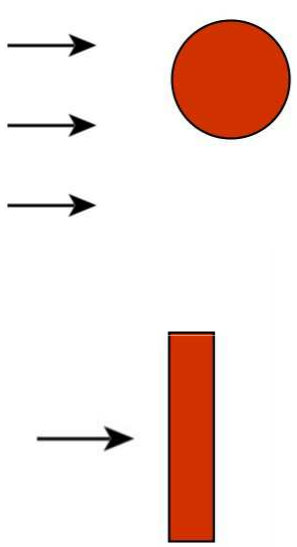
LIFT GALLOPING OF A RECTANGULAR SECTION



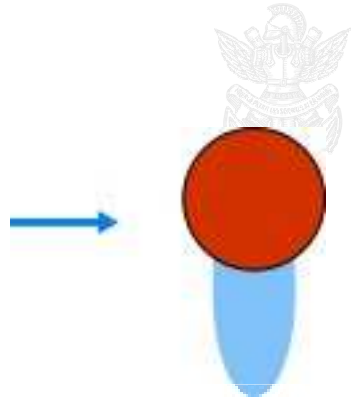


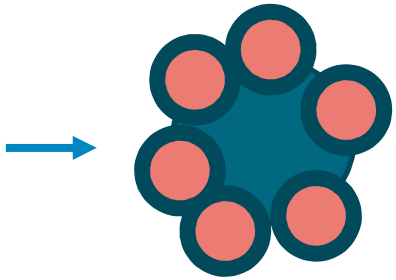


DRAG AND LIFT GALLOPING

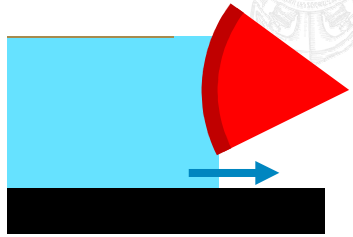


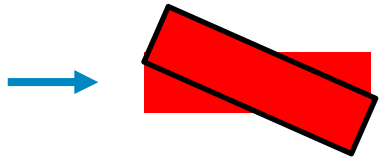
GALLOPING





GALLOPING





MODELS