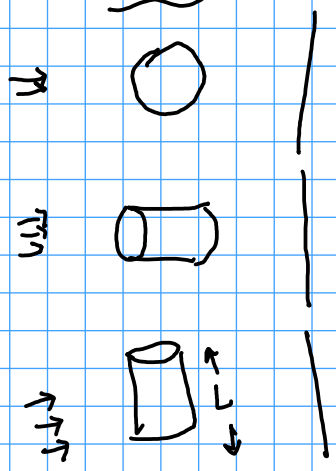
Lecture 10 - supplemental Example

Calculating a drag force

$$F_D = \frac{1}{2}\rho u^2 A_\perp C_D(Re)$$

$A_\perp$: projected area; C_D: drag coefficient

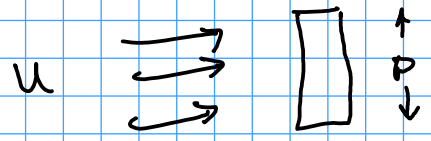
→ sphere, (cylinders, disks) ↓book



	$A_\perp$			
⇒	$\frac{\pi D^2}{4}$	(i) Laminar	$24/Re$	$Re < 10^2$
⇒	$\frac{\pi D^2}{4}$	(ii) turb wake, Laminar B.L.	0.445	$Re > 10^2$, $Re < 10^5$
⇒	DL	(iii) turbwake, Turb. BL.	0.19	$Re > 10^5$

Example: calculate the drag force on your hand out a car window when going 60 mph.

disk, $D = 10\,cm$



$u = 60\,mph$

$\rho = 1.18\,kg/m^3$ air

$\mu = 1.86 \times 10^{-5}\,Pa \cdot s$

$$u = 60\,\frac{mi}{hr} * \frac{1609\,m}{mi}\,\frac{hr}{3600\,s} = 26.82\,m/s$$

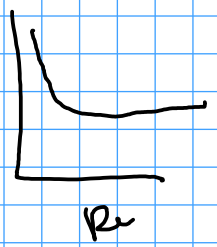
$$A_\perp = \frac{\pi D^2}{4} = \frac{\pi}{4}(0.1)^2\,m^2 = 0.00785\,m^2$$

(i) calculate Re

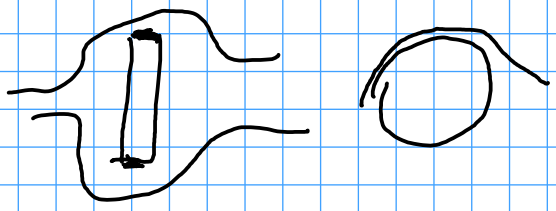
$$Re = \frac{\rho U D}{\mu} = \frac{1.18\ kg/m^3 \cdot 26.82\ m/s \cdot 0.1\ m}{1.86 \times 10^{-5}\ \frac{kg}{m \cdot s}} = 1.701 \times 10^5$$

(ii) Get C_D $C_D = 1.17$ $Re > 133$ p.57 p56

C_D



no region (iii) ?!



(iii) calculate F_D

$$F_D = \frac{1}{2} \rho U^2 A_1 C_D$$

$$= \frac{1}{2} \left(1.18 \frac{kg}{m^3}\right) \left(26.82 \frac{m}{s}\right)^2 (0.00785)\, m^2 (1.17)$$

$$= 3.90\ N \cdot \frac{1\ lbf}{4.44\ N} \approx \boxed{0.88\ lbf}$$