**MAE101B: Advanced Fluid Mechanics** Winter Quarter 2020

http://web.eng.ucsd.edu/~sgls/MAE101_2020/

# Quiz III

This is a 50 minute closed-book exam. Please put your name on the top sheet. Answer all three questions. Explain your working and state any assumptions you have made.

**1** (3 points) Circle the correct answer.

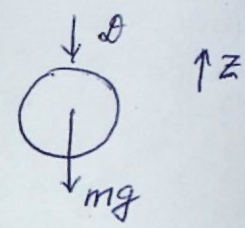
1. The Blasius equation
   - is a linear ordinary differential equation that can be solved anaytically.
   - is a partila differential equation.
   - is valid in the boundary layer over a smooth flat plate for laminar flow.
   - can be used to obtain pressure drag.
   - is obtained from the momentum integral equation assuming there is no pressure gradient along the plate.
2. As the Reynolds number increases for flow over a bluff body,
   - the drag coefficient always decreases .
   - the boundary layer disappears and the flow no longer satisfies the no-slip condition.
   - drag becomes equal to lift.
   - skin friction becomes negative.
   - there is a "drag crisis" at which the drag coefficient decreases.
3. Lift on an airfoil
   - is determined entirely by integrating the skin friction over the entire airfoil.
   - can be calculated using the Blasius equation.
   - is measured in bars.
   - is always parallel to gravity.
   - can be understood as resulting from a pressure difference due to circulation around the airfoil.

**2** (7 points) A nonspinning ball having a mass of 3 oz. is thrown vertically upward with a velocity of 100 mph and has zero velocity at a height 250 ft above the release point. Assume that the air drag on the ball is constant and find this constant "average" air drag. Neglect the buoyant force of air on the ball.

sol$^n$//.

$v_i = 100$ mph $= 146.67$ ft/s

$v_f = 0$ ft/s $\qquad s = 250$ ft




$v_f^2 - v_i^2 = 2as$

$$\Rightarrow a = \frac{-(146.67)^2}{2 \times 250} = -43.02 \text{ ft/s}^2$$

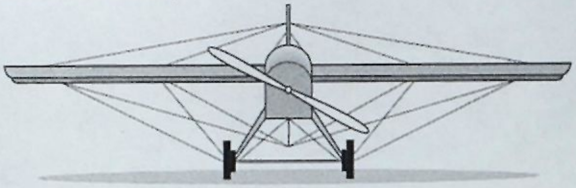
$ma = \Sigma F_z = D + mg \quad \Rightarrow D = m(a-g)$

$= (0.0058 \text{ slugs})[-43.02 + 32.2]$

$= -0.063$ lb

$D = 0.063$ lb in $-$ve z-direction

**3** (10 points) The wings of old airplanes are often strengthened by the use of wires that provided cross-bracing as shown in the figure. If the drag coefficient for the wings was 0.020 (based on the planform area), determine the ratio of the drag from the wire bracing to that from the wings. [Note that the frontal area of the wire is the product of its length and diameter.]



Speed: 70 mph
Wing area: 148 $ft^2$
Wire: length = 160 ft
diameter = 0.05 in.

Figure P9.106


$$D_{wing} = \frac{1}{2}\rho U^2 C_{D\,wing} A_{wing}$$

$$D_{wire} = \frac{1}{2}\rho U^2 C_{D\,wire} A_{wire}$$

$$\frac{D_{wire}}{D_{wing}} = \frac{C_{D\,wire} \cdot A_{wire}}{C_{D\,wing} A_{wing}}$$

$C_{D\,wing} = 0.02$

$A_{wing} = 148 ft^2$

$$A_{wire} = \ell D = (160 ft)\left(\frac{0.05}{12} ft\right) = 0.667 ft^2$$

$$Re = \frac{UD}{\nu} = \frac{\left(70 \times \frac{88}{60}\right)\left(\frac{0.05}{12}\right)}{1.57 \times 10^{-4}} = 2720$$

$\Rightarrow C_D = 1.0$

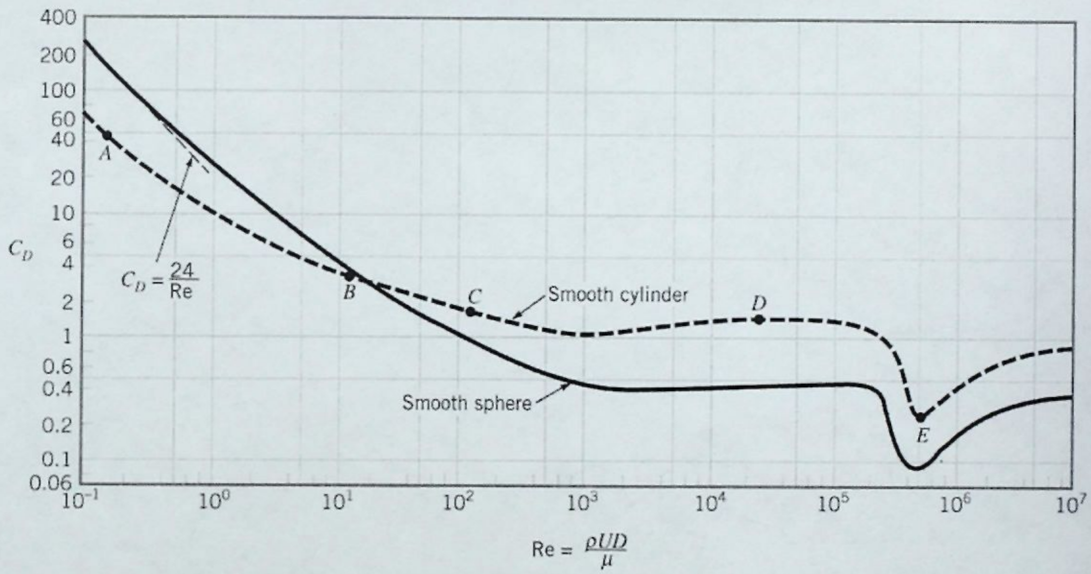
$$\therefore \frac{D_{wire}}{D_{wing}} = 0.225$$

# Useful values and parameters

**Units and constants**
1 hp = 550 lb ft/s
1 in = 2.54 cm
1 mph = 88 ft/min
Acceleration of gravity: 32.2 ft/$s^2$

**Material properties (in BG units)**
Air: $\rho = 0.00238$ slugs $ft^{-3}$, $\nu = 1.57 \times 10^{-4}$ $ft^2/s$.

**Drag on smooth cylinders and spheres as a function of Reynolds number**




(*a*)

Figure 9.21a