AEM 313: Practice Exam 1 Name: O'Neill

29th Sept 2016 75 minutes 6 Pages Closed books, Closed notes, Calculator

One page of notes.

100 total points **Read, think, plan, and then write.**

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Signature:_____

Date:_____

AEM 313: Practice Exam 1 Name:_____

Multiple Choice Problems: Circle **EVERY** correct answer [5 pts each]

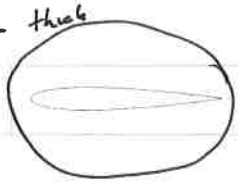
1. Which of the following are definitions of vorticity?

A. $\omega = \nabla \times V$	B. $\omega = \nabla \cdot V$	C. $\omega = \frac{dv}{dy} - \frac{du}{dx}$	D. $\omega = \frac{dv}{dx} - \frac{du}{dy}$	E. None of the above

2. How can a fluid particle's vorticity magnitude increase?

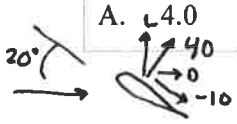
A. Never	B. Vortex Stretching	C. Unaligned Pressure and Density Gradients	D. Viscosity Shear Stress	E. None of the above

3. Which airfoil is an NACA 0012? Hint: camber thick

				None of the above

4. In a wind tunnel, a wing is mounted at 20 degrees AOA. The normal force is 40 lbs. The axial force is -10 lbs. What is the lift to drag ratio?

A. 4.0	B. -4.0	C. 0.78	D. 9.58	E. None of the above



$L = N\cos 20° - A\sin 20° = 40\cos 20° - (-10)\sin 20° = 41$

$D = N\sin 20° + A\cos 20°$

$= 4.28$

5. How many slugs are in one slinch?

slug $\frac{ft}{s^2}$ = lbf = slinch $\frac{in}{s^2}$ $\left|\frac{ft}{12in}\right.$

A. 12	B. 32.174	C. 1/12	D. 1/144	E. None of the above

6. Given the following symmetrical NACA 0012 airfoil, estimate C_m at the aerodynamic center.

A. 0	B. 0.12	C. -0.12	D. 2π	E. None of the above

$C_m = -\pi\frac{f}{c}$

$= 0$

7. A flow is irrotational and incompressible. Which of the following are true?

A. Zero Lift	B. Zero Drag	C. Zero Divergence	D. $\nabla \cdot V = 0$	E. $p + \frac{1}{2}\rho V^2 = p_0$

C

8. For an NACA 64_3-418 airfoil at Re=9 million, what is the drag coefficient at 0 degrees AOA? The experimental data is plotted below (source: Theory of Wing Sections)

A. 60 counts	B. -0.0620	C. 0.0055	D. 0.35	E. None of the above

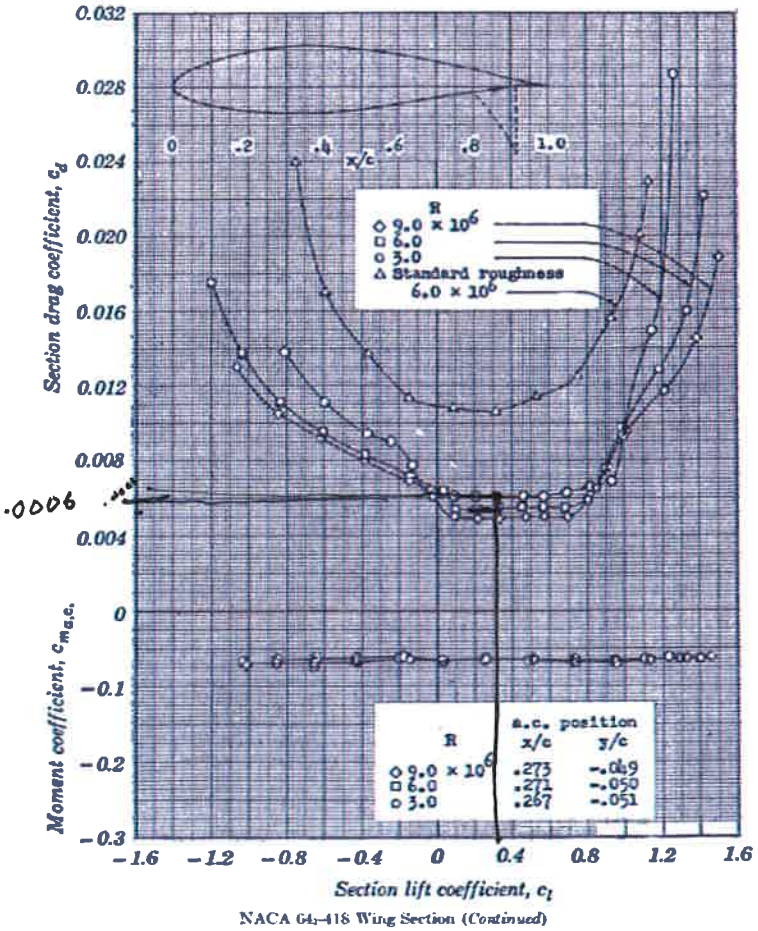
9. Given an unsteady flow, which of the following visualizes **a trace of all fluid elements that flowed through a fixed location**?

F. Pathline	G. Streakline	H. Timeline	I. Streamline	J. None of the above

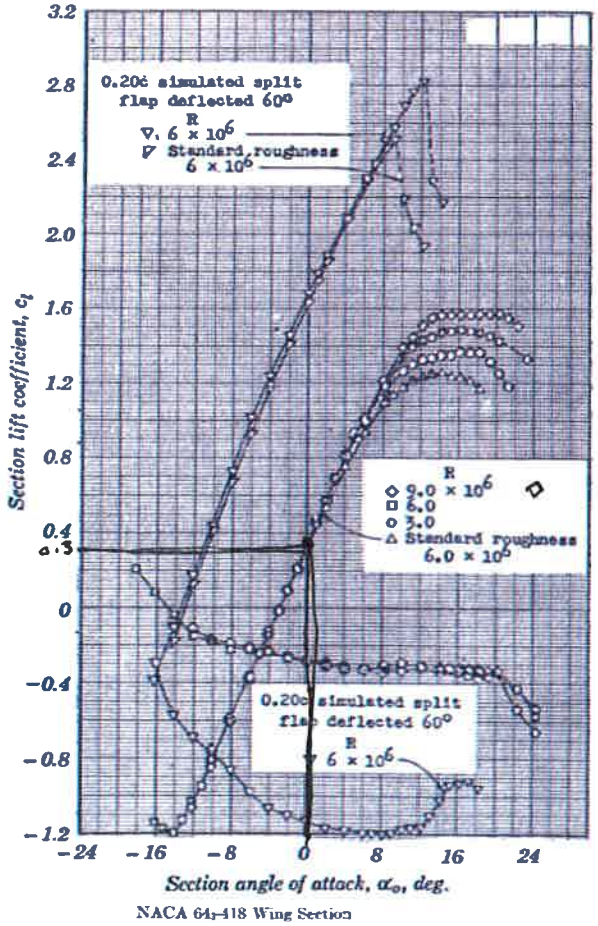
10. Given a 10% thick Joukowski airfoil at 10 degrees AOA, estimate C_{l_α} per radian? $C_{l_\alpha} = \frac{dC_l}{d\alpha}$

K. 6.87	L. 20π	M. 0.11	N. 2π	O. None of the above

$C_{l_\alpha} \approx 2\pi \frac{1+\epsilon}{1+\epsilon^2} =$ $\epsilon = 0.77 \frac{t}{c}$



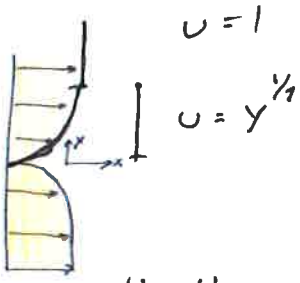
NACA 64₁-418 Wing Section (*Continued*)



NACA 64₁-418 Wing Section

11. [20 pts] A flat plate with a chord of 1 foot and span of 10 feet generates a downstream wake described by:

$$u(y) = \begin{cases} y^{1/7} & 0 < y < 1 \\ (-y)^{1/7} & -1 < y < 0 \\ 1 & \text{otherwise.} \end{cases}$$



The upstream velocity is V=1. The distance y is measured in feet.

$U_1 - U_2 = 1 - y^{1/7}$

What is the sectional drag coefficient C_d?

$$D = \int \rho_2 U_2 (U_1 - U_2)\, dy = 2\int_0^1 \rho_2 U_2 (U_1 - U_2)\, dy = 2\int_0^1 \rho_2\, y^{1/7}\left(1 - y^{1/7}\right) dy$$

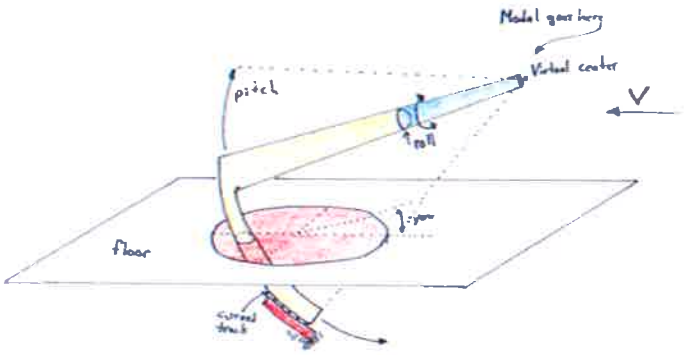
$$= 2\rho_2 \int_0^1 \left(y^{1/7} - y^{2/7}\right) dy = \frac{7}{8} y^{8/7} - \frac{7}{9} y^{9/7}\Big|_0^1 = \left(\frac{7}{8} - \frac{7}{9}\right) - (0-0)$$

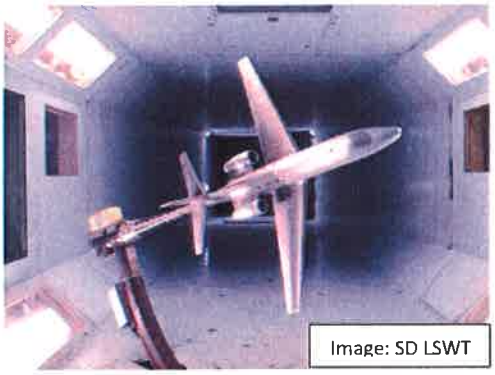
$$= \underline{2\rho_2} \cdot \frac{7}{72}$$

$$C_d = \frac{D}{\frac{1}{2}\rho V^2 c} = \frac{2\rho_2 \cdot (2)}{\rho V^2 \cdot 1} \cdot \frac{7}{72} = \frac{7}{18}$$

$$\boxed{C_d = \frac{7}{18}}$$

12. [10 pts] A wind-tunnel model is connected to the following sting in a level attitude. The sting is initially pointed directly into the freestream velocity vector. The sting's roll mount is rotated right to ϕ=90°. The sting's pitch mount is rotated up to θ=30°. Then the sting's yaw mount is rotated left to ψ=-30° (note the minus). **Determine α and β of the model with respect to the freestream.**





$$\begin{matrix} u \\ v \\ w \end{matrix} = \begin{matrix} C_\theta C_\psi \\ S_\phi S_\theta C_\psi - C_\phi S_\psi \\ C_\phi S_\theta C_\psi + S_\phi S_\psi \end{matrix}$$

$C_\theta = C(30)$

$$= \begin{matrix} 0.75 \\ 0.433 \\ -0.5 \end{matrix}$$

mag = 1 ✓

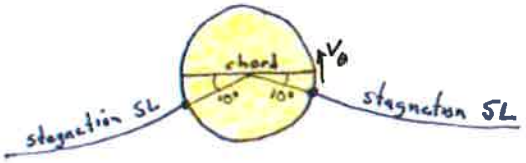
$u^2 + v^2 + w^2$

$$\alpha = \text{atan}\left(\frac{w}{u}\right) = \text{atan}\left(\frac{-0.5}{0.75}\right) = -45.08^\circ \quad -33.7^\circ$$

$$\beta = \text{asin}\left(\frac{v}{V}\right) = \text{asin}(0.433) = 24^\circ$$

$\alpha = -45^\circ$
$\beta = 24^\circ$

13. [20 pts] Given a cylinder of radius 10 inches in a freestream flow of 100 ft/s at SSL, you measure stagnation points at -10 degrees below the chordline. What is the lift generated per unit span?



$\frac{d}{dr}\left(-R^2 r^{-2}\right)$

$$\psi = V_\infty r \sin\theta \left(1 - \frac{R^2}{r^2}\right) + \frac{\Gamma}{2\pi}\ln\left(\frac{r}{R}\right) \qquad V_r(r=R) = 0$$

find Γ such that V_θ at $-10^\circ = 0$

$$V_\theta = -\frac{d\psi}{dr} = -V_\infty \sin\theta\left(1 - \frac{R^2}{r^2}\right) + -V_\infty r \sin\theta\left((-)(-2)\frac{R^2}{r^3}\right) + \frac{-\Gamma}{2\pi}\frac{1}{r}$$

$$= -V_\infty \sin\theta\left(1 - \frac{R^2}{r^2} + 2\frac{R^2}{r^2}\right) + \frac{-\Gamma}{2\pi r} \qquad \left(1 + \frac{R^2}{r^2}\right)$$

$$V_\theta(\theta = -10^\circ) = 0 \Rightarrow \Gamma = -V_\infty \sin(-10^\circ)(1+1)\cdot 2\pi \cdot R \qquad \left(-\tfrac{\pi}{18}\right)$$

$$= \frac{\pi^2}{18} \cdot 4 \cdot V_\infty \cdot R$$

$$L' = \rho V \Gamma = \rho V_\infty \frac{\pi^2}{18} 4 V_\infty R$$

$$= \rho V_\infty^2 \pi^2 \frac{4}{18} R$$

$$= 0.00237 \frac{\text{slug}}{\text{ft}^3} \left|\frac{100^2 \text{ft}^2}{\text{s}^2}\right| \pi^2 \left|\frac{4}{18}\right| 10\text{in} \left|\frac{\text{ft}}{12\text{in}}\right| \frac{\text{lbf s}^2}{\text{slug ft}}$$

$$\boxed{L' = 43 \text{ lbf/ft}}$$

$\oint c_p \cdot \hat{n}\, ds$

$$C_p = 1 - \frac{V^2}{V_\infty^2}$$