AEM 313: Exam C Name: O'Neill

27th Sept 2017 50 minutes 5 Pages Open book, Open notes, Calculator, Ruler

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

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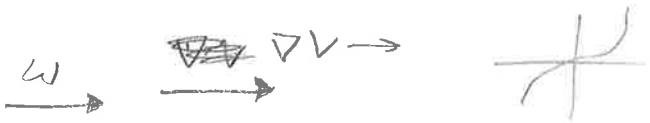
Signature:_____

Date:_____

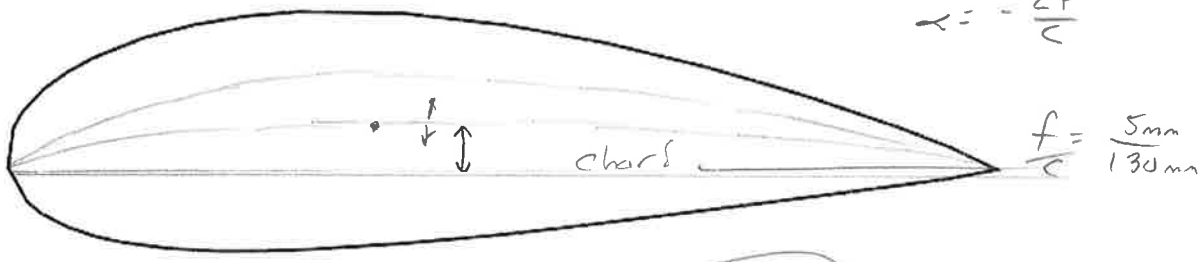
Multiple Choice Problems: [5 pts each]



1. A blob of fluid with vorticity $\omega = 1$ in the x-direction (i.e. $\omega = 1\hat{x} + 0\hat{y} + 0\hat{z}$) encounters accelerating flow in the x-direction (i.e. $V = x^3\,\hat{x}$). What happens to the vorticity magnitude?

Increases	Nothing	Decreases	Changes direction	Exponentially decays to zero

2. Given the following airfoil, estimate the zero lift AOA in degrees.



$\alpha = -\frac{2 \cdot 5}{130} \cdot \frac{180^\circ}{\pi} = -4.4$

3. What is the divergence of a 2D flow with $V = x\hat{i} + xy\,\hat{j} + z^2\hat{k}$ at z = 0 and x = -1?

0	1/2	1	y	None of the above

$\nabla \cdot V = \frac{d}{dx}(x) + \frac{d}{dy}(xy) + \frac{d}{dz}(z^2)$

$1 + x^{-1} + 2z^0$

4. For an NACA 64_3-418 airfoil at Re=6 million, what is the drag coefficient at +6 degrees AOA? The experimental data is plotted below (source: Theory of Wing Sections) 0.0095

60 counts	140 counts	80 counts	95 counts	None of the above

5. What is the wingspan of a wing with: 250 square foot area, AR=10, and zero taper ratio? $AR = \frac{b^2}{S}$

2500	50	35	25	0

$b = \sqrt{SAR}$

6. For a 2D thin airfoil, what is the slope of the lift coefficient curve $dC_l / d\alpha$ [1/rad]?

0 deg	$1/\pi$	$4\sin^2(\alpha)\cos(\alpha)$	2π	None of the above

7. Estimate the SSL stall speed of a Fokker Triplane (S=201 ft^2, W=1300 lbf) given the maximum lift coefficient is 2.2.

35 ft/s	45 mph	50 ft/s	55 ft/s	2480 ft/s

$L = W = \frac{1}{2}\rho V^2 S C_{L_{max}} \Rightarrow V = \frac{W \cdot 2}{\rho S C_{L_{max}}} \Rightarrow$

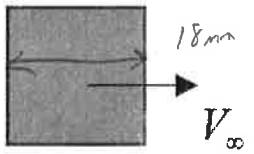
8. An NACA 4321 has a _____

Thickness of 4%	Max Camber of 3% c	Max camber at 21% c	Max Thickness at 30% c	Max camber at 40%

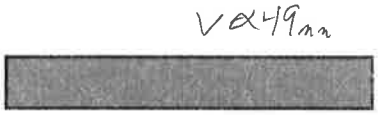
9. What is the air density in slug/ft^3 at 80° F and 14.7 psi? $p = \rho RT$

459.67+80 = 0.00278 $\rho = \frac{P}{RT} =$ 14.7 lb/in^2 | 1717 ft^2/s^2°R | 539.67 °R | 144 in^2/ft^2 | slug ft / lbf s^2 | 1/ft

10. In an incompressible flow at time t=0, you create a timeline-streakline box A at the freestream velocity. At a future time t=1, the box has distorted to box B. Compute the average pressure coefficient at B.



A



B

0	0.96	-7.3	-2π	None of the above

$C_p = 1 - \frac{V^2}{V_\infty^2} = 1 - \frac{49^2}{18^2}$

-6.4

$\epsilon \approx 0.77\% \; 0.26 = 0.2$

$C_{l_\alpha} = 2\pi \frac{1+\epsilon}{1+\epsilon^2}$

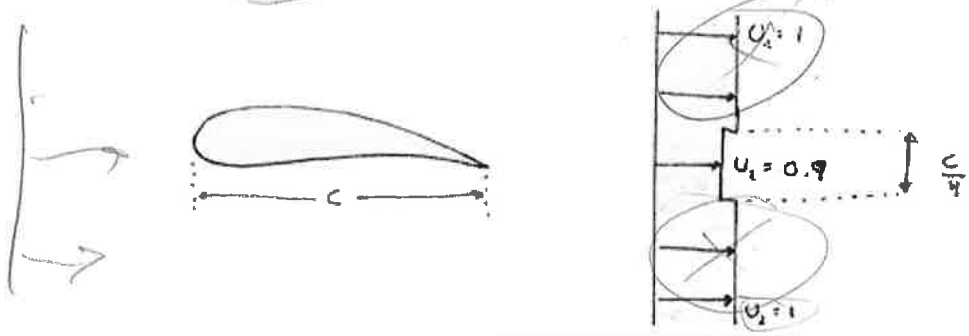
11. Given a 26% thick symmetrical Joukowski airfoil at 10 degrees AOA, estimate C_l?

1.26	2π	$2\pi \cdot 1.15$	$2\pi \cdot 1.18$	72.5

$2\pi \frac{1.2}{1.04} =$

$C_l = C_{l_\alpha} \alpha$ 10

12. An airfoil with a chord of "c" creates a uniform velocity of 0.9 with a thickness of c/4. The upstream velocity is U_1=1. Determine the sectional drag coefficient C_d.



$D = \int \rho U_2 (U_1 - U_2)\, dl$

$= \rho \int_{c/4}^{0.1} 0.9(1.0 - 0.9)\, dl$

$D = \rho \int_0^{c/4} 0.09$

$= \rho \, 0.09 \, c/4$

$C_D = \frac{D}{\frac{1}{2}\rho V^2 c} = \frac{2\rho 0.09 c/4}{\rho c}$

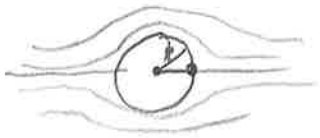
0.045

13. What is the temperature at 10000 ft on a standard day?

10 F	23 F	59 F	223 F	483 R K

$59 - 0.0035$

14. Compute the velocity vector at x=1 and y=0 for the streamfunction



$$\psi(r,\theta) = V_\infty r \sin(\theta)\left(1 - \frac{R^2}{r^2}\right)$$

F.S + D

0

15. What is the Reynolds number of a 10 inch airfoil operating at SSL and 100 ft/s?

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

530 000

$R_e = 6350 \; V^{ft/s} \cdot L^{ft}$

$100 \quad 10/12$

16. An aircraft is rotated to the following Euler angles: $\psi = 0$, $\theta = 90^\circ$, $\phi = 90^\circ$. Compute the angle of attack.

0 deg	45 deg	90 deg	180 deg	None of the above

$\text{atan} \frac{0}{0}$

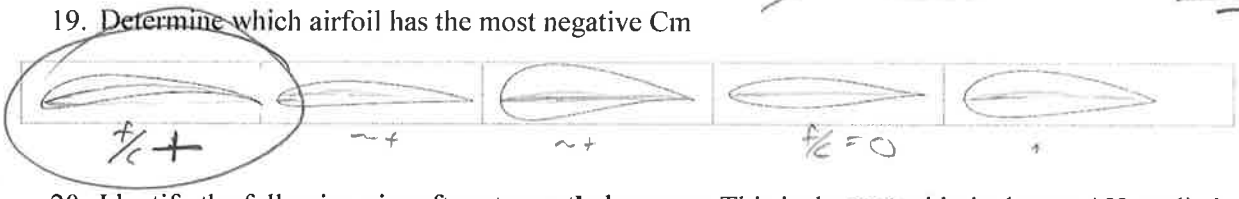
17. How does increasing camber affect the lift generation at a constant AOA (e.g. 0 degrees)?

No effect	Increases Cl	Decreases Cl	Increases the Lift Slope C_{l_α}	None of the above

18. Fundamentally, why do airfoils generate lift with a lift curve slope of 2π ?

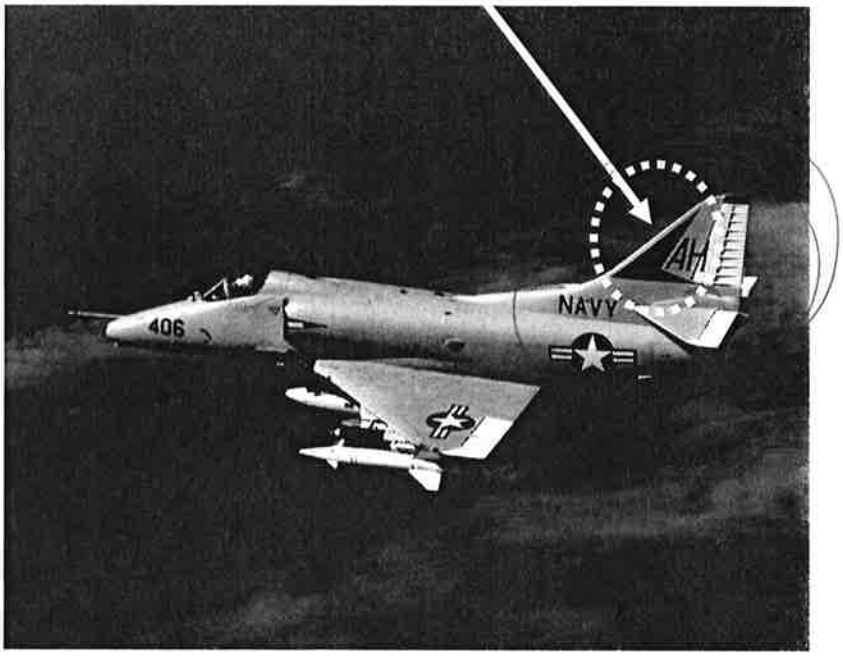
2π is arbitrary	Thickness	Sharp TE	Kutta Joukowski $\rho V\Gamma$	I don't know

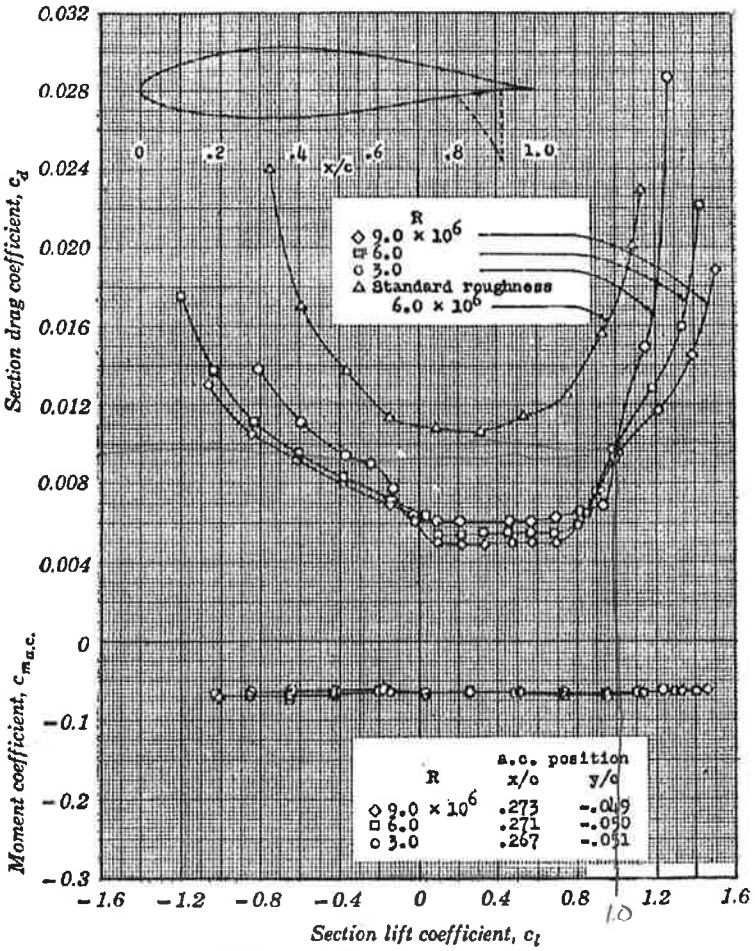
19. Determine which airfoil has the most negative Cm



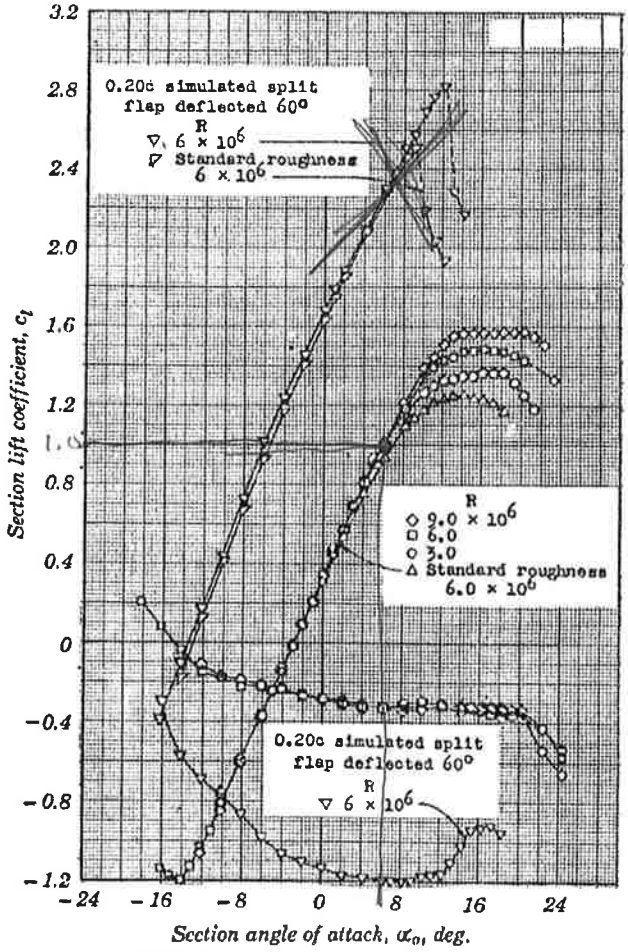
20. Identify the following aircraft part **exactly** by name. This is the part with the letters AH applied.

Vertical Stab





NACA 64$_3$-418 Wing Section (*Continued*)



NACA 64$_3$-418 Wing Section