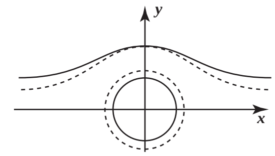
Ö. Savaş NAME: **SOLUTIONS**

11:10-12:00, Friday, October 15, 2004

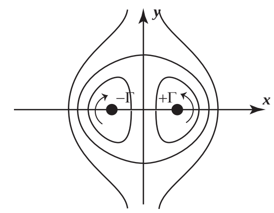
ME-163 ENGINEERING AERODYNAMICS
MIDTERM EXAM – open book

1.(25%) Consider uniform flow past a fixed cylinder of radius a. Using the potential flow solution, write the equation of the streamline passing through $(r, \theta) = (2a, \pi/2)$. Sketch the streamline. If the diameter of the cylinder starts to expand, how does that streamline change? Sketch the new streamlines with respect to the first one anchored at $(2a, \pi/2)$.



$\psi = Ur\ sin\theta(1 - \frac{a^2}{r^2})$, streamline through $(r, \theta) = (2a, \pi/2)$ $\psi_{(2a,\pi/2)} = 3Ua/2 \implies \frac{2}{3}\frac{r}{a}\ sin\theta(1 - \frac{a^2}{r^2}) = 1$

2.(25%) Consider the two point vortices of equal and opposite strengths $\mp\Gamma$ placed at $(x, y) = (\mp a, 0)$. Determine the uniform flow (U, V) needed for the vortices to remain stationary. Determine the stagnation points. Sketch the streamline pattern. In particular, sketch the shape of the straemlines passing though the stagnation points. Determine the height and width of the oval outlined by the closed streamline.



$(U, V) = (0, \Gamma/4\pi a)$, $(x, y)_{sp} = (0, \mp\sqrt{3}a)$, stream function $\psi = -Vx + (\Gamma/2\pi)\ ln\{[(x + a)^2 + y^2]/[(x - a)^2 + y^2]\}$, stagnation streamline $\psi = 0$ on $x/a = ln\{[(x + a)^2 + y^2]/[(x - a)^2 + y^2]\}$ which crosses x-axis at $x/a = 0$ & ∓ 2.087

3.(25%) The new jumbo jet, Airbus A380 is designed to fly at 13km altitude at Mach number 0.85. Its wing span is about 80m, and average chord 10m. Its gross cruise weight is about $5 \cdot 10^6$N. Assuming incompressible flow, determine the lift coefficient of the aircraft. If its wing were a symmetrical airfoil, what would be the angle of attack.

$$C_L = \frac{L}{\frac{1}{2}\rho U^2 A} = \frac{5 \cdot 10^6}{\frac{1}{2} \times 0.265 \times (0.85 \times 295)^2 \times 10 \times 80} = 0.75 \implies \alpha = \frac{C_L}{2\pi} = \frac{0.75}{2\pi} = 0.12rad = 6.8^\circ$$

4.(25%) The atmosphere of Venus is almost all CO_2. Near its surface, the pressure is 92 bars (1 bar = 10^5 Pa) and temperature 480°C. What will be the reading of a Pitot-static tube mounted on a spacecraft which is descending at $M = 0.5$. The specific heat ratio for CO_2 is $\gamma = 1.30$.

$u = aM = M\sqrt{\gamma RT} = 0.5 \times \sqrt{1.30 \times (8.3145/0.044) \times (480 + 273)} = 0.5 \times 430 = 215\ m/s$

$\rho = p/RT = 92 \cdot 10^5/[(8.3145/0.044) \times (480 + 273)] = 64.66\ kg/m^3$

$\frac{1}{2}u^2 + \frac{\gamma}{\gamma-1}\frac{p}{\rho} = cons \implies \frac{p_0}{\rho_0} = \frac{p}{\rho}\left(1 + \frac{\gamma-1}{2\gamma}\ \frac{\rho}{p}\ u^2\right)$ & $\frac{p}{\rho^\gamma} = cons \implies \frac{p_0}{p} = \left(1 + \frac{\gamma-1}{2\gamma}\ \frac{\rho}{p}\ u^2\right)^{\gamma/(\gamma-1)}$

$\frac{p_0}{p} = \left(1 + \frac{1.3-1}{2\times1.3}\ \frac{64.66}{92\cdot10^5}\ 215^2\right)^{1.3/(1.3-1)} = 1.173 \implies \Delta p = p_0 - p = 0.173p = 15.9 \cdot 10^5\ Pa$
