

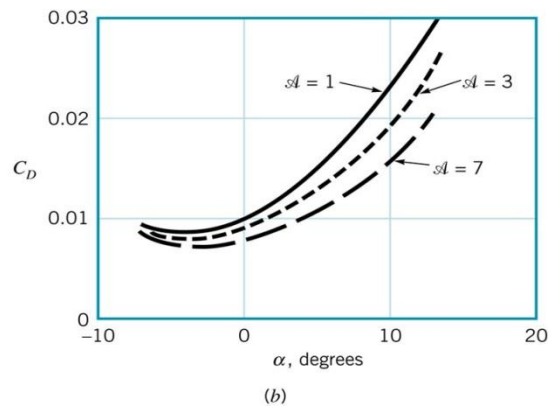
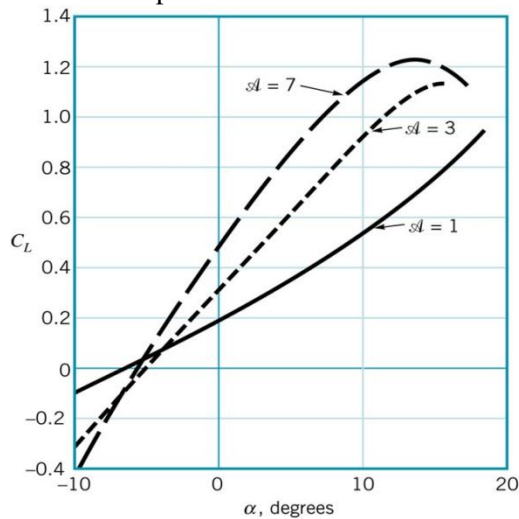
**CONCORDIA UNIVERSITY**  
**DEPARTMENT OF MECHANICAL AND INDUSTRIAL ENGINEERING**  
**FINAL EXAMINATION**  
**FLUID MECHANICS II MECH 361**  
**WINTER 2012**

**Instructor: Dr. Nabil Esmail**

**This is a three hours closed book exam. Solve all questions. Only faculty approved calculators are allowed. Consult the attached equations, Moody diagram, and isentropic tables (at the end) for additional information that may be required to solve the problems.**

**Question No. 1. (15 marks)**

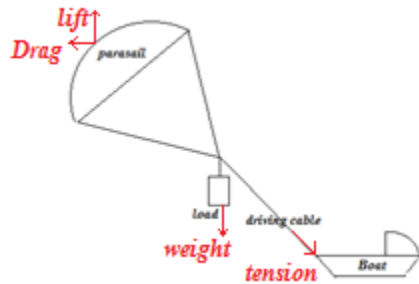
- a) Explain why planes land and takeoff against the wind.  
Magnus, higher lift at lower plane speed, air is streaming faster over the wing
- b) Explain why planes generate trailing vortices off the end of their wings.  
By design pressure differences top and bottom. At wing end pressures create vortices
- c) Explain the situation when the plane stalls.  
Separation point moves sharply to the front destroying the upper wing pressure
- d) Explain how aerodynamics is used in sports
  - (1) Golf balls and Enhance turbulence smaller wake
  - (2) Cricket balls Depending on positions of seems top and bottom, player manipulate trajectory
- e) Explain the relationship between the planform area and the aspect ratio of plane's wing for different planes.



A is the aspect ratio is the square of the wing's span over the actual wing area. For a square wing  $A=1$ . The longer the span compared to cord the higher the ratio A. Square wings give lowest lift and highest drag. Lift-drag performance improves with higher ratios. However manoeuver-ability suffers.

**Question No. 2. (20 marks)** In steady state operation (system moving at a constant horizontal speed),

- a) Define all the external forces exerted on the system consisting of the parasail, the load and the driving cable, which is pulled by the boat. DRAW A SKETCH IN THE ANSWERS BOOKLET.

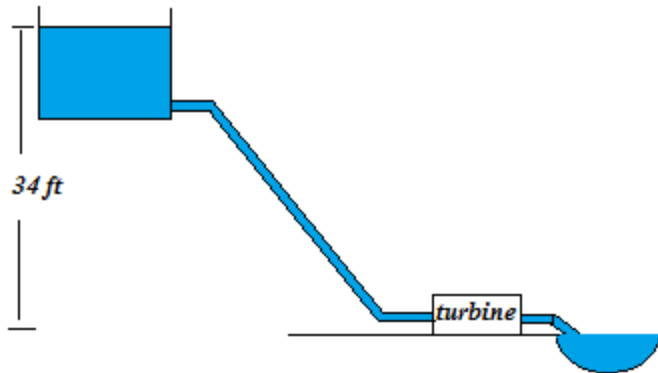


- b) Assuming a certain maximum load  $W$ , list all the design parameters.  
 1. Pulling tension, 2. Diameter, 3. Boat speed, 4. Length of cord, 5. Lift coefficient, 6. Drag coefficient, 7. Properties (density) of air
- c) What are the variables that will affect the height of the load in steady state operation and how do they affect?  
 1. Boat speed (tension), 2. Shape of parachute (lift and drag coefficients) 3. Air density
- d) What should one do to increase the load and keep the same height and speed in steady state operation?  
 1. Increase diameter to increase the lift.

**Question No. 3.** (15 marks) A rocket is fired in a straight horizontal path to an explosive target one km above earth. An observer on the ground is equipped with a sound activated stop watch. The temperature is  $15^\circ\text{C}$ , the universal gas constant is  $R = 287\text{ J/kg.K}$ ,  $k = 1.4$ . What does the observer conclude if the equipment will record:

- a) Only one sound?  
 Subsonic rocket, or supersonic with distance=square root of  $\text{Mach}^2-1$
- b) Two separated sounds?  
 Supersonic with distance longer than square root of  $\text{Mach}^2-1$
- c) What is the relationship between Mach number of the rocket and the observer's ground distance from the target in each of a) and b).  
 a)  $d = \sqrt{M^2 - 1}$ , b)  $d > \sqrt{M^2 - 1}$

**Question No. 4.** (20 marks) A small stream of water of  $Q=2$  cfs (cubic feet per second) at temperature  $40^\circ\text{F}$  is falling from an elevation of  $H=34$  ft above ground. It is planned to divert this stream into a commercial-grade plastic pipe (absolute roughness  $e=1.2 \cdot 10^{-5}$  ft) that will supply an electric-generating turbine located on the ground. The plastic supply pipe is 87 ft long. The maximum acceptable head loss in the supply pipe is 3 ft. Neglecting minor losses find the minimum diameter that can be used for the supply pipe. Assume that pipes are available in even sizes 2 in., 4 in., ...etc.



$$\frac{\Delta p}{\rho} = gh = 32.17 \times 34 = 1,093.78, \quad \text{head loss} = 3g = 96.51 \text{ ft}^2/\text{s}^2,$$

$$h = f \frac{L}{D} \frac{V^2}{2}, \quad Q = 2 \text{ ft}^3/\text{s}, \quad Q = VA = V \left( \frac{\pi D^2}{4} \right), \quad V = \frac{4Q}{\pi} \left( \frac{1}{D^2} \right), \quad L = 87 \text{ ft},$$

$$Re = \frac{\rho V D}{\mu} = \frac{4\rho Q}{\pi \mu} \left( \frac{1}{D} \right), \quad e = 0.000012 \text{ ft}, \quad \frac{e}{D} = 0.000012 \left( \frac{1}{D} \right)$$

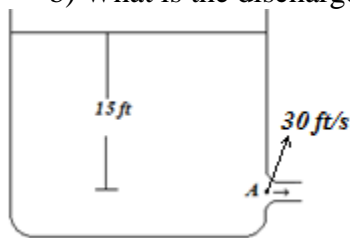
$$\frac{1}{\sqrt{f}} = -2 \log \left( \frac{e}{3.7065D} + \frac{2.5226}{Re \sqrt{f}} \right)$$

Algorithm of solution

1. Assume a Diameter, 2. Calculate V and Re and e/D, 3. Find f
4. use  $h = f \frac{L}{D} \frac{V^2}{2} = 96.51 \text{ ft}^2/\text{s}^2$ , to find  $D = f \frac{L}{96.51} \frac{V^2}{2}$

**Question No. 5.** (15 marks). The velocity at point A of the discharge pipe from a large water ( $\rho = 62.4 \text{ lb}/\text{ft}^3$ ) reservoir is 30 ft/s. The point A is located 15 ft from the water surface. Because of the rounded entrance to the discharge pipe the flow is considered irrotational. Atmospheric pressure is 14.7 psi, and gravity  $g=32.17 \text{ ft}/\text{s}^2$ .

- a) What is the pressure at point A?
- b) What is the discharge velocity?



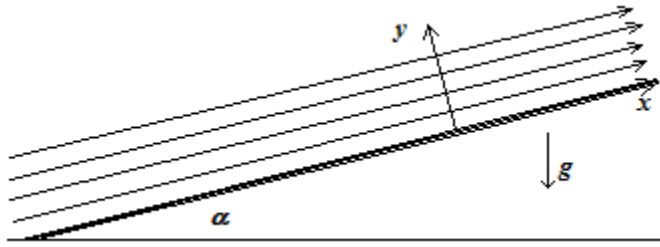
$$p + \frac{\rho V^2}{2} + \rho gh = \text{const},$$

$$p_{atm} + \rho gh = p_A + \frac{62.4 * 900}{2 * 32.17}, \quad p_A = p_{atm} + \frac{(62.4 * 32.17 * 15)}{32.17} - 872.9$$

$$= p_{atm} + 936 - 872.9, \quad p_A - p_{atm} = 63.1 \text{ lb}_f/\text{ft}^2 = 0.44 \text{ psig}$$

$$V_{discharge} = \sqrt{2gh} = 31.07 \text{ ft/s}$$

**Question No. 6.** (15 Marks) Using the Navier-Stokes equation find the pressure distribution in the y-direction for the parallel flow ( $v_y = 0, v_z = 0$ ) adjacent to a wall inclined to the horizontal by  $\alpha$ . Direction of gravity is indicated on the figure below.



$$\frac{\partial p}{\partial x} = -\rho g \sin \alpha, \quad p = -\rho g \sin \alpha \cdot x + f_1(y),$$
$$\frac{\partial p}{\partial y} = \rho g \cos \alpha, \quad p = \rho g \cos \alpha \cdot y + f_2(x), \quad \text{finally } p = \rho g \cos \alpha \cdot y - \rho g \sin \alpha \cdot x$$

\*\*\*\*\* End of Questions \*\*\*\*\*