

## JOUKOWSKY FOIL LAB

PURPOSE: The main purpose of this lab is to measure the pressures on a Joukowski foil and to use these pressures to compute the lift on the foil.

PROCEDURE: Fix the flow speed  $S$ . Measure the flow speed. Vary the angle of attack  $\theta$  of the foil. For each  $\theta$ , measure the pressures on the foil.

REPORT: Use the pressures to calculate the lift on the foil per unit span. The lift is:

$$\Sigma P \Delta c \sin(\theta - \theta)$$

Plot the lift versus the angle of attack. Compare the experimental lift with the theoretical lift  $\rho \Gamma S$ . The theoretical drag is zero. The actual drag is:

$$\Sigma P \Delta c \cos(\theta - \theta)$$

Plot the drag versus the angle of attack.

## FOIL THEORY

Joukowski foils are obtained by mapping a circle into a foil shape using the mapping function

$$\alpha = x + [xa^2/(x^2+y^2)] \quad \beta = y - [ya^2/(x^2+y^2)]$$

Geometry gives

$$\begin{aligned} x &= \mathbf{X} - n & y &= \mathbf{Y} + m \\ \mathbf{X} &= -R \cos\Upsilon & \mathbf{Y} &= +R \sin\Upsilon \\ a &= \sqrt{[R^2 - m^2]} - n \end{aligned}$$

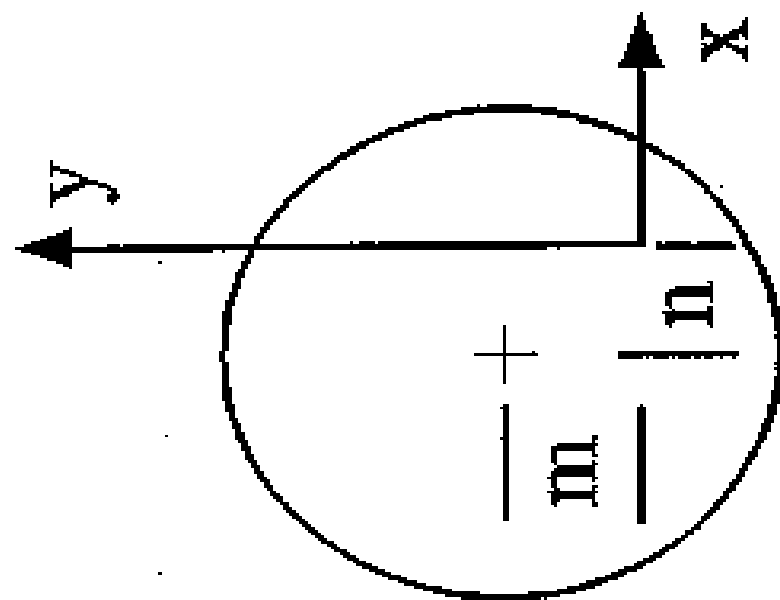
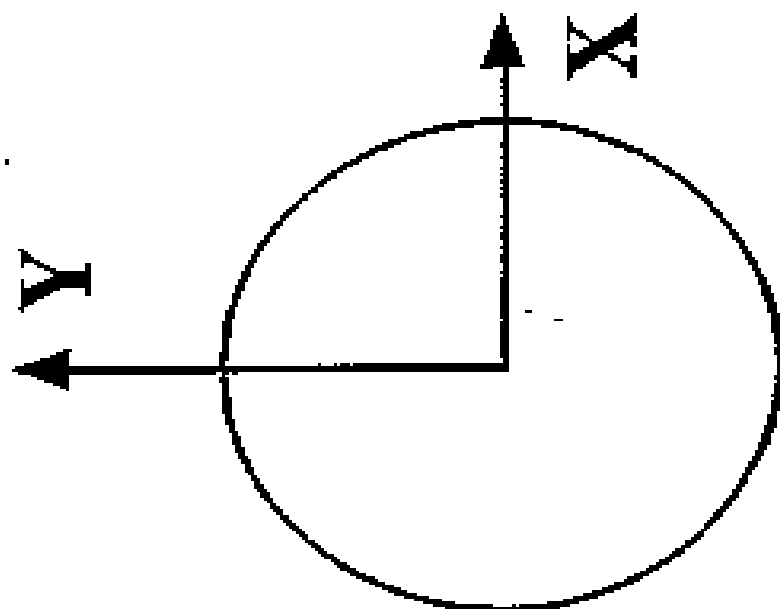
The lift on the foil per unit span is

$$\rho \Gamma S$$

where  $\Gamma$  is the foil circulation and  $\rho$  is the air density. The circulation can be calculated using:

$$\Gamma = 4\pi S R \sin(\theta + \varepsilon) \quad \varepsilon = \tan^{-1}[m/(n+a)]$$

For the lab foil, the circle radius  $R$  is 55mm and offset  $m$  is 10mm and the offset  $n$  is 5mm.



POINTS		$\Delta C$	$\theta$
1T	2T	1.01109	325.23206
2T	3T	0.99685	304.09503
3T	4T	0.99976	295.58853
4T	5T	0.99867	289.77145
5T	6T	0.99691	285.06308
6T	7T	0.99926	281.13855
7T	8T	0.99719	277.75861
8T	9T	0.99859	274.37634
9T	10T	0.99848	271.31189
10T	11T	0.99854	268.54242
11T	12T	0.99822	265.91437
12T	13T	0.99747	263.27313
13T	14T	0.99723	261.20947
14T	15T	0.99976	258.71863
15T	16T	0.99743	256.60071
16T	17T	0.99825	254.65540
17T	18T	0.99778	252.67206
18T	19T	0.99282	252.12128
19T	20T	1.00230	248.44128
20T	21T	1.00230	248.44128
21T	22T	0.99667	247.68335

POINTS		$\Delta C$	$\theta$
1B	2B	1.00035	56.39056
2B	3B	0.99861	91.60328
3B	4B	0.99685	97.61395
4B	5B	0.99968	99.65379
5B	6B	0.99735	100.56589
6B	7B	0.99939	100.39603
7B	8B	0.99760	99.82207
8B	9B	0.99802	99.07877
9B	10B	0.99753	97.98315
10B	11B	0.99941	96.42060
11B	12B	0.99689	94.96974
12B	13B	0.99739	93.35789
13B	14B	0.99854	91.45760
14B	15B	0.99825	89.56265
15B	16B	0.99927	87.37759
16B	17B	0.99689	85.03027
17B	18B	1.00187	81.39737
18B	19B	0.99936	81.37561
19B	20B	1.03574	79.54431
20B	21B	1.03528	79.68259

