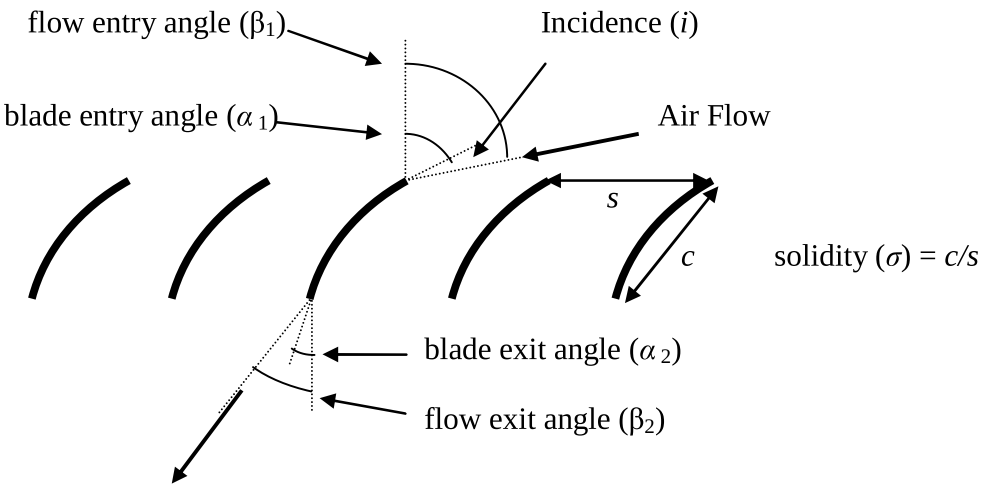
ECOR 1606 Final Lab Test Sample #2

The diagram below depicts a row of blades in an air compressor.



The designer knows the flow entry angle (β_1), the desired flow exit angle (β_2) and the desired *incidence* (i). He (or she) must select the *solidity* (σ) of the row, the blade entry angle (α_1), and the blade exit angle (α_2).

Important note: Angles are in degrees throughout. All of the formulae assume degrees.

Choosing the blade entry angle is easy.

$$\alpha_1 = \beta_1 - i$$

A suitable solidity value may be obtained by solving the equation below.

$$33.5291 + (0.469188 + 0.0020961\beta_2)\beta_2 - \beta_1 + (0.187148\beta_2 - 15.2599)\ln(1/\sigma) - 0.677212\left(\ln(1/\sigma)\right)^2 = 0$$

Write a **function**, ***computeSolidity***, that takes β_1 and β_2, and computes and returns σ. There are a number of ways of solving the equation. You are to use a brute force approach. No great accuracy is required (the choice of a solidity value is in any case somewhat subjective) and the number of values that need be considered is therefore limited. Have your function evaluate the left hand side of the equation for solidity values ranging from 0.6 to 2.1 (in steps of 0.1) and have it select the value that comes closest to satisfying the equation (i.e. that makes the left hand side closest to zero).

To assist you in debugging your code, the function in the sample executable prints out a table showing the results of its calculations. Your function must do likewise. The columns of the table must line up, solidity values must be displayed with one decimal place, and computed values must be displayed with four decimal places.

Once the blade entry angle and the solidity have been determined, the blade exit angle that will give the desired flow exit angle can be determined using the following equation.

$$\alpha_2 = \frac{\beta_2 - \alpha_1\left(0.23 + \frac{\beta_2}{500}\right)\left(\frac{1}{\sigma}\right)^{0.5}}{1 - \left(0.23 + \frac{\beta_2}{500}\right)\left(\frac{1}{\sigma}\right)^{0.5}}$$

Write a **function**, ***computeBladeExitAngle***, that takes α_1, β_2, and σ, and computes and returns α_2.

Your functions must correspond exactly to the specifications given.

Write a C++ **program** ("***practice2.cpp***") that repeatedly reads in design scenarios (flow entry angle β_1, desired flow exit angle β_2, and desired incidence i), until -1 -1 -1 is entered. For each set of values entered your program should either i) output an error message (if the entered values are invalid -- see next paragraph) or ii) compute and output values for the blade entry angle, the row solidity, and the blade exit angle.

The flow exit angle β_2 must be between -10 and 50 degrees, the incidence i must be between -3 and 3 degrees, and the value of

$$\frac{36 - 0.45\beta_2}{\beta_1 - \beta_2}$$

must be between 0.75 and 1.25. All of these ranges are inclusive of the specified values. Be sure to consider the possibility that the values entered for β_1 and β_2 may be equal.

Note: Your program must include and use the two required functions described above.

Test Run #1

```
Enter flow entry angle, flow exit angle, and incidence: 40 0 0

  Solidity     LHS Value
----------------------------
     0.6       -14.4428
     0.7       -11.9999
     0.8        -9.9098
     0.9        -8.0862
```

```
     1.0        -6.4709
     1.1        -5.0226
     1.2        -3.7112
     1.3        -2.5139
     1.4        -1.4130
     1.5        -0.3949
     1.6         0.5517
     1.7         1.4358
     1.8         2.2647
     1.9         3.0447
     2.0         3.7811
     2.1         4.4782
Leaving function. The chosen value is 1.5

Blade entry angle: 40.0
Soldidity: 1.5
Blade exit angle: -9.2

Enter flow entry angle, flow exit angle, and incidence: 10 10 0
Invalid values ignored.
Enter flow entry angle, flow exit angle, and incidence: 20 10 0
Invalid values ignored
Enter flow entry angle, flow exit angle, and incidence: 60 40 0

  Solidity     LHS Value
----------------------------
     0.6        -8.4975
     0.7        -7.2086
     0.8        -6.1181
     0.9        -5.1762
     1.0        -4.3496
     1.1        -3.6148
     1.2        -2.9548
     1.3        -2.3566
     1.4        -1.8106
     1.5        -1.3089
     1.6        -0.8454
     1.7        -0.4152
     1.8        -0.0142
     1.9         0.3611
     2.0         0.7135
     2.1         1.0454
Leaving function. The chosen value is 1.8

Blade entry angle: 60.0
Soldidity: 1.8
Blade exit angle: 34.0

Enter flow entry angle, flow exit angle, and incidence: 30 30 0
Invalid values ignored.
Enter flow entry angle, flow exit angle, and incidence: -1 -1 -1
Press any key to continue . . .
```

Test Run #2

```
Enter flow entry angle, flow exit angle, and incidence: 33.1 0 0

  Solidity     LHS Value
----------------------------
     0.6        -7.5428
     0.7        -5.0999
     0.8        -3.0098
     0.9        -1.1862
```

```
     1.0         0.4291
     1.1         1.8774
     1.2         3.1888
     1.3         4.3861
     1.4         5.4870
     1.5         6.5051
     1.6         7.4517
     1.7         8.3358
     1.8         9.1647
     1.9         9.9447
     2.0        10.6811
     2.1        11.3782
Leaving function. The chosen value is 1.0

Blade entry angle: 33.1
Soldidity: 1.0
Blade exit angle: -9.9

Enter flow entry angle, flow exit angle, and incidence: 41.6 -9.999 1

  Solidity     LHS Value
----------------------------
     0.6       -21.4805
     0.7       -18.7492
     0.8       -16.4092
     0.9       -14.3652
     1.0       -12.5527
     1.1       -10.9261
     1.2        -9.4519
     1.3        -8.1047
     1.4        -6.8652
     1.5        -5.7180
     1.6        -4.6506
     1.7        -3.6531
     1.8        -2.7172
     1.9        -1.8360
     2.0        -1.0037
     2.1        -0.2153
Leaving function. The chosen value is 2.1

Blade entry angle: 40.6
Soldidity: 2.1
Blade exit angle: -18.6

Enter flow entry angle, flow exit angle, and incidence: 40 0 4
Invalid values ignored
Enter flow entry angle, flow exit angle, and incidence: 40 0 -4
Invalid values ignored
Enter flow entry angle, flow exit angle, and incidence: 41.6 -10.01 1
Invalid values ignored
Enter flow entry angle, flow exit angle, and incidence: 50 -9.999 0
Invalid values ignored
Enter flow entry angle, flow exit angle, and incidence: 46.7 -9.999 1
Invalid values ignored
Enter flow entry angle, flow exit angle, and incidence: 60 -9.999 1
Invalid values ignored
Enter flow entry angle, flow exit angle, and incidence: 31.4 10.9 2
Invalid values ignored
Enter flow entry angle, flow exit angle, and incidence: 40 0 -3.1
Invalid values ignored
Enter flow entry angle, flow exit angle, and incidence: 60 10 0
Invalid values ignored
Enter flow entry angle, flow exit angle, and incidence: 15 10 0
```

```
Invalid values ignored
Enter flow entry angle, flow exit angle, and incidence: -1 -1 -1
Press any key to continue . . .
```