Started on	Wednesday, 10 August 2022, 11:05 AM
State	Finished
Completed on	Wednesday, 10 August 2022, 11:10 AM
Time taken	4 mins 39 secs
Marks	1.00/1.00
Grade	**0.50** out of 0.50 (**100**%)

Question **1**

Correct

Mark 1.00 out of 1.00

Consider the non-dimensional functional form of the lift on a NACA XXXX airfoil

$$\frac{L'}{0.5\rho_\infty U_\infty^2 c} = \hat{f}\left(\alpha, \frac{\rho_\infty U_\infty c}{\mu_\infty}, \frac{U_\infty}{a_\infty}, \frac{t}{c}, \frac{m}{c}, \frac{p}{c}\right),$$

where t, m and p are respectively the maximum thickness, maximum camber and location of maximum camber. All other symbols have their usual meaning. It is well-known that the non-dimensionalization of a functional relation is not unique. Which of the following functional forms is an **INCORRECT** representation of the above similarity relation? Note that the question is not about relative utility of the various functional forms, but about their mathematical admissibility from dimensional analysis.

Select one:

a. $\frac{L'}{0.5\rho_\infty U_\infty^2 c} = \hat{j}\left(\alpha, \frac{\rho_\infty U_\infty c}{\mu_\infty}, \frac{\rho_\infty a_\infty c}{\mu_\infty}, \frac{tm}{c^2}, \frac{m}{c}, \frac{p}{c}\right)$

b. $\frac{L'}{0.5\rho_\infty a_\infty^2 t} = \hat{g}\left(\alpha, \frac{\rho_\infty a_\infty t}{\mu_\infty}, \frac{a_\infty}{U_\infty}, \frac{c}{t}, \frac{m}{t}, \frac{p}{t}\right)$

c. $\frac{L'}{0.5\rho_\infty U_\infty^2 c} = \hat{h}\left(\alpha, \frac{\rho_\infty a_\infty c}{\mu_\infty}, \frac{U_\infty t}{a_\infty c}, \frac{t}{c}, \frac{mp}{c^2}\right)$ ✔

d. $\frac{L'}{0.5\rho_\infty U_\infty^2 c} = \hat{k}\left(\alpha, \frac{\rho_\infty a_\infty c}{\mu_\infty}, \frac{U_\infty}{a_\infty}, \frac{\rho_\infty U_\infty^2 mtp}{\mu_\infty a_\infty c^2}, \frac{m}{c}, \frac{pm}{ct}\right)$

Your answer is correct.

We started with 10 parameters (including L') spanning 3 fundamental dimensions (M, L and T). Per Buckingham's pi theorem, we should end up with 10 - 3 = 7 non-dimensional groups. Thus, the one solution having 6 non-dimensional groups is immediately suspicious. In all the other three options, we have 7 non-dimensional groups (check this), and all of them are independent of each other. Thus, they are all mathematically valid representations of the given similarity function.

The correct answer is: $\frac{L'}{0.5\rho_\infty U_\infty^2 c} = \hat{h}\left(\alpha, \frac{\rho_\infty a_\infty c}{\mu_\infty}, \frac{U_\infty t}{a_\infty c}, \frac{t}{c}, \frac{mp}{c^2}\right)$

◄ Tu5.2: Tutorial on thickness problem

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QzS2 ►