

16/ENG04/019

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Electrical and Electronics Engineering:

Question

A flat plate of mass m falling freely in air with velocity V is subjected to a downward gravitational force and an upward frictional drag force due to air. If the drag force F_D is given by Equation (1).

$$F_D = \frac{0.3V^2}{500 + (\ln V)^3}$$

and the terminal velocity is reached when the drag force equal the gravitational force, that is $F_D = mg$. If taking the values of m and g to be 3.5 kg and 9.8 m/s^2 respectively, using a guess value of $V_0 = 0$ and employing fixed-point iteration method, develop a MATLAB program to estimate the terminal velocity. Take the absolute percentage relative error tolerance to be less than or equal to $1E-11$.

Solution

$$F_D = mg$$

$$m = 3.5;$$

$$g = 9.8$$

$$F_D = 3.5 \times 9.8$$

$$= 34.3$$

Hence,

$$34.3 = \frac{0.3V^2}{500 + (\ln V)^3}$$

$$34.3 = \frac{0.3V^2}{500 + (\ln V)^3}$$

$$34.3 = \frac{0.3v^2 - (500 + (\ln v)^3)(0.02v)}{(500 + (\ln v)^3)}$$

$$17150 + (34.3 (\ln v)^3) = 0.3v^2 - (10v + 0.02v(\ln v)^3)$$

$$17150 + 34.3 (\ln v)^3 = 0.3v^2 - 10v - 0.02v (\ln v)^3$$

$$17150 + 34.3 (\ln v)^3 + 10v + 0.02v (\ln v)^3 = 0.3v^2$$

$$10v = 0.3v^2 - 0.02v (\ln v)^3 - 34.3 (\ln v)^3 - 17150$$

$$10v = 0.3v^2 - 0.02v (\ln v)^3 - 34.3 (\ln v)^3 - 17150$$

$$v = \frac{0.3v^2 - 0.02v (\ln v)^3 - 34.3 (\ln v)^3 - 17150}{10}$$

$$v_{i+1} = \frac{0.3v_i^2 - 0.02v_i (\ln v_i)^3 - 34.3 (\ln v_i)^3 - 17150}{10}$$

$$v_{i+1} = 0.03v_i^2 - 0.02v_i \ln(v_i)^3 - 34.3 (\ln v_i)^3 - 1715$$

CODE

$$v^2 = \frac{17150}{0.3}$$

$$0.3v^2 = 17150 + 34.3 (\ln v)^3 + 10v + 0.02v (\ln v)^3$$

$$v^2 = \frac{17150}{0.3} + \frac{34.3}{0.3} (\ln v)^3 + \frac{10}{0.3} v + \frac{0.02}{0.3} v (\ln v)^3$$

$$v^2 = 57166.67 + 114.33 (\ln v)^3 + 33.33v + 0.0667v (\ln v)^3$$

$$v = \text{Sqrt}((34.4 + 0.02 * v) * (500 + (\log(v(i)) * 3)) / 3);$$

Matlab code

Command window

Clear

clc

format short g

v = 0.5


```

for i = 1: inf
    v(i+1) = i
    v(i+1) = sqrt((34.4 + 0.02 * v(i)) * (500 + log(v(i))^3))
    Ea(i+1) = abs((v(i+1) - v(i)) / v(i+1)) * 100;
    If = Ea(i+1) <= 1e-11
        break
    end
end
table = [iwr' v' Ea'];

```

Command window.

table	0	10-5	0
0	1	239.4	99.791
1	2	294.6	18.737
2	3	303.05	2.7883
3	4	304.29	0.40956
4	5	304.48	0.060091
5	6	304.5	0.0088058
6	7	304.51	0.001291
7	8	304.51	0.00018927
8	9	304.51	2.7749e-05
9	10	304.51	4.0682e-06
10	11	304.51	5.9644e-07
11	12	304.51	8.7442e-08
12	13	304.51	1.282e-08
13	14	304.51	1.8775e-09
14	15	304.51	2.7355e-10
15	16	304.51	4.0396e-11
16	17	304.51	5.9362e-12
17		304.51	