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MECHANICAL ENGINEERING

ENG 382 : ENGINEERING MATHEMATICS IV

Question:

A plate (flat) 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 eqn (1).

$$F_D = \frac{0.3V^2}{500 + (\ln V)^3} - 0.02V \quad \text{— (1)}$$

and the terminal velocity is reached when the drag force equals the gravitational force equals the gravitational force, that is; $F_D = mg$ — (2) taking the values of m and g to be 3.5kg and $9.8 m/s^2$ respectively, using a guess value of $V_0 = 0.5$ m/s, & 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:

$$F_D = \frac{0.3V^2}{500+(\ln V)^3} - 0.02V \quad \text{— ①}$$

$$F_D = mg = 3.5 \times 9.8 = 34.3 \quad \text{— ②}$$

Equating eqns ① & ②

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

making V^2 subject of formular

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

$$0.3V^2 = (34.4 + 0.02V) * (500 + (\ln V)^3)$$

$$V^2 = ((34.4 + 0.02V) * (500 + (\ln V)^3)) / 0.3$$

$$V = \sqrt{((34.4 + 0.02V) * (500 + (\ln V)^3)) / 0.3)}$$

from the question;

Initial guess value $\Rightarrow V_0 = 0.5 m/s$

Absolute % relative error, $\varepsilon a(i+1) \leq 1E-11$.

MATLAB PROGRAM CODE

```
1-  command window
2-  clear
3-  clc
4-  close all
5-  format short g
6-  syms V
7-  V = 0.5
8-  for i = 1 : inf
9-      iter(i+1) = i;
10-     V(i+1) = (((34.3+(0.02*V(i)))*(500+(log(V(i)))^3
                                  ))/0.3)^0.5;
11-     Ea(i+1) = abs((V(i+1)-V(i))/V(i+1)) * 100;
12-     if Ea(i+1) <= 1E-11
13-         break
14-     end
15- end
16- table = [iter' V' Ea']
```

The estimated terminal velocity is **304.07 m/s** //

substituting in eqn ① ; $F_A = 34.3005 \approx mg = 34.3$ //