CEE450 final project

Xiaowen Lin

1. Code

```
clear all;
clc;

xa=0; xb=10; F0=0; G0=0; GInf=1; s=1;
N=1000; delta=1e-6; Nmax=1000;


step = (xb-xa) / N;
x = linspace(xa, xb, N+1);

F = linspace(0, 0, N+1); %  F
G = linspace(0, 0, N+1); %  first order F
H = linspace(0, 0, N+1); %  second order F

Fv = linspace(0, 0, N+1); %  df/ds
Gv = linspace(0, 0, N+1); %  dG/ds
Hv = linspace(0,0,N+1); %  dH/ds

iter = 0;

while iter < Nmax
    F(1) = F0;
    G(1) = G0;
    H(1) = s;
    Fv(1) = 0;
    Gv(1) = 1;
    Hv(1) = 1;

    for i = 1:N
        F(i+1) = F(i) + G(i)*step;
        G(i+1) = G(i) + H(i)*step;
        H(i+1) = H(i) -0.5*F(i)*H(i)*step;

        Fv(i+1) = Fv(i) + Gv(i)*step;
        Gv(i+1) = Gv(i) + Hv(i)*step;
        Hv(i+1) = Hv(i) + 0.5*H(i)*Fv(i)*step;
    end
    iter = iter + 1;
    s = s - (G(N+1)-GInf) / Gv(N+1);
    if abs((G(N+1)-GInf) / Gv(N+1)) < delta
        break;
    end
end

fprintf('The value for s is %.2f\n', s);
plot(x,F,'-',x,G,'--',x,H,':');
leg1 = legend('F','G','H');
set(leg1,'Location','NorthWest');
print -djpeg FGH.jpg;
```

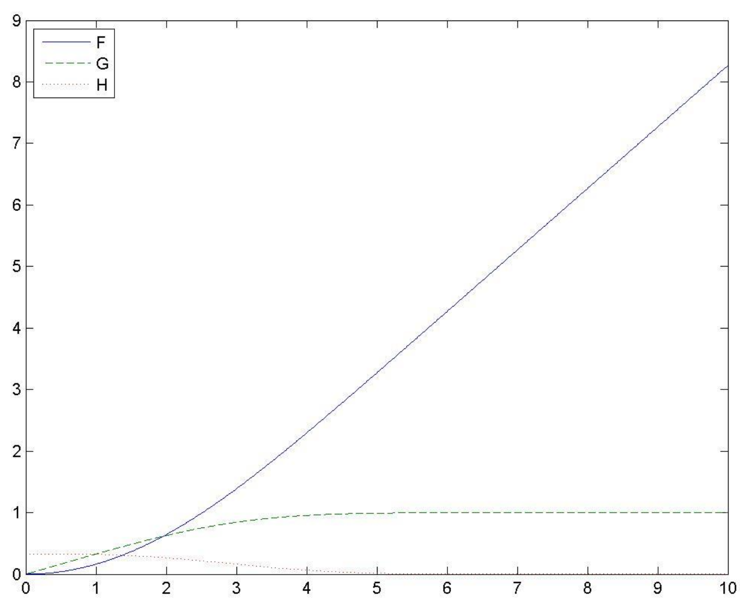
```
close;


plot(x,G);
leg2 = legend('G');
set(leg2,'Location','NorthWest');
hold on;
plot(x,0.99);
hold off;
print -djpeg G.jpg;
close;

I = 1:1001;
index = I(G>0.99);
index = index(1);
fprintf('The F" nearest to 0.99 is %f and %f.\n', G(index-1), G(index));
fprintf('The corresponding values of eta is %f and %f.\n', x(index-1),
x(index));
fprintf('The value of eta99 is %.2f\n', x(index-1)+(0.99-G(index-
1))*(x(index)-x(index-1))/(G(index)-G(index-1)));

rho = 1.24; %  kg/m3
L = 0.2; b = 0.1; v = 1.5e-5; %  m2/s
U = [0.01, 0.1, 0.5];
FD = 0.66*b*U.*sqrt(v*U*L);
```

2. Output of MATLAB



The value for s is 0.33

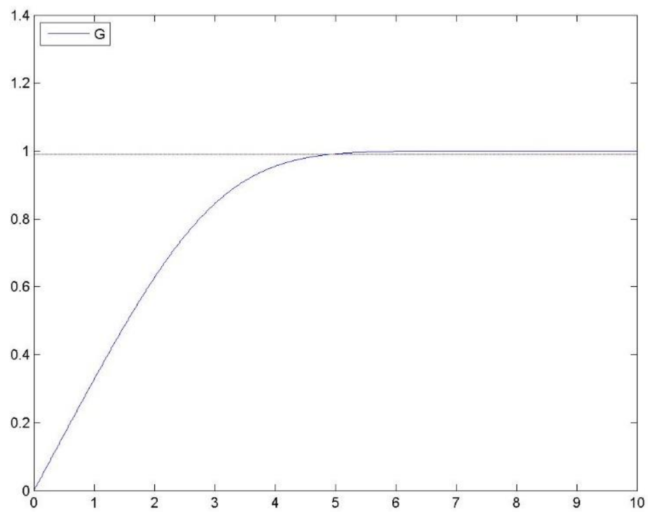
The F" nearest to 0.99 is 0.989931 and 0.990116.

The corresponding values of eta is 4.910000 and 4.920000.

The value of eta99 is 4.91

3. Solution

1. Use the solution to plot u/U as a function of η.



Value of η99 is 4.913746.2 as it shows in the console output of "matlab".

$$\delta\sqrt{\frac{U}{vx}} = 4.91$$

$$\delta = 4.91\sqrt{\frac{vx}{U}}$$

For the boundary shear stress on the body

$$\frac{\partial u}{\partial y} = U\sqrt{\frac{U}{vx}}F''(\eta)$$

$$\frac{\tau o}{\rho U^2} = \frac{\rho v\frac{\partial u}{\partial y}}{\rho U^2} = \sqrt{\frac{v}{xU}}F''(\eta) = Re^{-\frac{1}{2}}F''(\eta) = Re^{-\frac{1}{2}}F''\left(0\times\sqrt{\frac{U}{vx}}\right) = Re^{-\frac{1}{2}}F''(0)$$

$$\frac{\tau o}{\rho U^2} = 0.33\times\sqrt{\frac{v}{xU}} = 0.33\times Re^{-1/2}$$

For drag force

$$\frac{F_D}{\rho bLU^2} = \frac{1}{bL}\iint\frac{\tau o}{\rho U^2}dA = \frac{1}{L}\int_0^L\frac{\tau o}{\rho U^2}dx = 0.33\times\frac{1}{L}\int_0^L\sqrt{\frac{v}{xU}}dx = \frac{0.33}{L}\sqrt{\frac{v}{U}}\int_0^L\sqrt{\frac{1}{x}}dx = 0.66\sqrt{\frac{v}{UL}}$$

$$F_D = 0.66\rho bU\sqrt{vUL}$$

According to the result form "matlab", the drag force is 1.1 E-7, 3.61 E-6, 4.04 E-5.