Background: The motivation behind the experiment is to find the flow rate in a pipe if the velocity is known at discrete points along the radius of the pipe.

Exercises to do (A 1000 points but the points do not matter):
Use Matlab to solve problems (2 thru 6). Use comments, display commands and fprintf statements, and sensible variable names to explain your work. Staple all the work in the following sequence.

0. Signed typed affidavit sheet.
1. Handwritten data taken in the lab on a separate sheet of paper. This should have your name, group number, date on it.
2. Find the regression curve that relates the velocity of the water as a function of the radius.
3. Illustrate the plot of the data points and the regression curve.
4. Find the flow rate of the water using the regression curve found in #2.
5. Find the flow rate from the (Average velocity × Area) formula.
6. Use another scientific method of your choice to find the flow rate.
7. In 100-200 words, type out your conclusions using a word processor. Any formulas should be shown using an equation editor. Any sketches need to be drawn using a drawing software such as Word Drawing. Any plots can be imported from MATLAB.
Semester: Summer 2008

EML3041 Affidavit Sheet

Important: Each student is expected to work independently on the computer program. Offenders will be assigned a grade of FF for the whole course and brought to the attention of the Dean of academic affairs for further process. Check 2007-08 undergraduate catalog on academic dishonesty and disruption of academic process. I attest to the following.

I have

1. worked independently,
2. received no help on this programming assignment from anybody (other than instructor or TA), and
3. given no help in completing the programming assignment

during Summer 2008 for the course - EML 3041- Computational Methods.

If I am found to be giving or receiving help, I will be assigned a grade of 'FF' for the whole course and brought to the attention of the Dean of Academic Affairs for further process. Check 2007-08 undergraduate catalog on academic dishonesty and disruption of academic process. You always have the right to appeal the decision of the instructor.

Name of the Project: Flow rate in pipe

Dated June 02, 2008

Signature AK

Name Autor K Kaw
<table>
<thead>
<tr>
<th>r (ft)</th>
<th>v(r) (ft/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10.0</td>
</tr>
<tr>
<td>0.083</td>
<td>9.72</td>
</tr>
<tr>
<td>0.17</td>
<td>8.88</td>
</tr>
<tr>
<td>0.25</td>
<td>7.50</td>
</tr>
<tr>
<td>0.33</td>
<td>5.60</td>
</tr>
<tr>
<td>0.42</td>
<td>3.10</td>
</tr>
<tr>
<td>0.50</td>
<td>0.00</td>
</tr>
</tbody>
</table>
% GROUP 5
% Autar Kaw
% EML3041
% Summer 2008

% This worksheet demonstrates finding the flow rate in a pipe
% when the velocity vs radius data is given

clear all

disp('Group 5')
disp('Autar Kaw')
disp('EML3041')
disp('Summer 2008')
disp('Flow rate in a pipe')
disp('******************************')
disp('
')

% Problem 1
% Attached is the handwritten data taken in the lab
% Radial location data
radial = [0 0.083 0.17 0.25 0.33 0.42 0.5];
% Velocity data
velocity = [10 9.72 8.88 7.5 5.6 3.1 0];
disp('Problem 1')
disp('See attached data sheet')
disp('******************************')
disp('
')

% Problem 2
% Length of radial location array
n=length(radial);
% Fitting a polynomial of degree 2 to the data
p=polyfit(radial,velocity,2);
syms r
% Outputting the velocity profile
disp('Problem 2')
fprintf('The velocity profile is %gr^2 + %gr + %g', p(1), p(2), p(3))
disp('
')
disp('******************************')
disp('
')

% Problem 3
% Plotting velocity vs radial location
r_val=radial(1):(radial(n)-radial(1))/1000:radial(n);
v_val=polyval(p,r_val);
plot(radial,velocity,'o', r_val, v_val,'-');
xlabel('Radial Location, ft')
ylabel('Velocity, ft/s')
title('Velocity vs radial location plot')
legend('Experimental data','Regression Curve')
disp('Problem 3')
disp('See attached plot')
disp('******************************************')
disp('')

%Problem 4
% Finding the flow rate from the regression curve
% Velocity profile
vel_profile=p(1)*r^2+p(2)*r+p(3);
% Integrating to find the flow rate
flow_rate=int(2*pi*r*vel_profile,r,radosial(1),radosial(n));
flow_rate=double(flow_rate);
disp('Problem 4')
fprintf('The flow rate from the regression curve is %g ft^3/s',flow_rate)
disp('')
disp('******************************************')
disp('')

%Problem 5
% Finding the flow rate from the average velocity x Area method
% Average Velocity
avg_vel=mean(veloocity);
% Integrating to find the flow rate
flow_rate=avg_vel*pi*radosial(n)^2;
flow_rate=double(flow_rate);
disp('Problem 5')
fprintf('The flow rate from the average velocity method is %g ft^3/s',flow_rate)
disp('')
disp('******************************************')
disp('')

%Problem 6
% Using trapezoidal rule with unequal segments to find flow rate
flow_rate_alt=0;
for i=1:n-1
    fun_up=2*pi*radosial(i+1)*velocity(i+1);
    fun_low=2*pi*radosial(i)*velocity(i);
    flow_annulus=(radosial(i+1)-radosial(i))/2*(fun_up+fun_low);
    flow_rate_alt=flow_rate_alt+flow_annulus;
end
disp('Problem 6')
disp('Using trapezoidal rule with unequal segments to find flow rate')
fprintf('The flow rate from an alternative method is %g ft^3/s',flow_rate_alt)
disp('')
disp('******************************************')
disp('')
Group 5
Autar Kaw
EML3041
Summer 2008
Flow rate in a pipe

Problem 1
See attached data sheet

Problem 2
The velocity profile is \(-39.9209r^2 + 0.067263r + 9.9965\)

Problem 3
See attached plot

Problem 4
The flow rate from the regression curve is \(3.94962 \text{ ft}^3/\text{s}\)

Problem 5
The flow rate from the average velocity method is \(5.02655 \text{ ft}^3/\text{s}\)

Problem 6
Using trapezoidal rule with unequal segments to find flow rate.
The flow rate from an alternative method is \(3.84767 \text{ ft}^3/\text{s}\)
Conclusions

Autar Kaw
Group 5
Summer 2008
Flow Rate Project

The flow rate $Q$ in a pipe is given by

$$Q = \int_0^a v(r) dr = \int_0^a 2 \pi r v(r) dr$$  \hspace{1cm} (1)

where

$v(r) =$ velocity along the radial location, $r$

$a =$ radius of the pipe.

I used three methods of finding the flow rate.

1. In the first case, the velocity vs radial location data was regressed to a second order polynomial and then substituted in equation (1).

2. In the second method, the average velocity $\bar{V}$ was found and the flow rate was simply given by

$$Q = \bar{V} \times A$$

where $A$ is the cross-sectional area of the pipe.

3. In the method of my choice, I chose the Trapezoidal rule with unequal segments.

So why are the results from methods (1) and (3) so different from method (2)?
This is because the integrand in equation (1) is $2 \pi r v(r)$ and not $v(r)$. If I had averaged $2 \pi r v(r)$ instead, I would get a better estimate of the flow rate just like obtained in Methods (1) and (3). I would have tried this method also as a learning experience, but I had ICE and HVAC tests to study for and I promised my BFF that I will go to see Sex and the City with her.