REPORT

ASSIGNMENT 1, Python in ChemE

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Problem statement

In this assignment we were required to compare the analytical and numerically calculated terminal velocity of a sphere in a medium of given density and viscosity.

Attempted solution

Physics of problem

Three forces act on the spherical object: Viscous force, Buoyant force, and gravitational force.

The equation of motion can be written as:

$m\,du/dt = mg - \rho V g - 6\pi r \eta u$

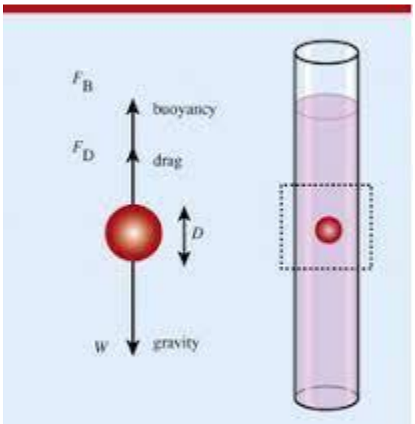

Figure 1. Schematic representation of the forces applied to the falling ball in the liquid.

m=mass of sphere
u=velocity of sphere
g=gravitational acceleration
ρ=density of fluid
V=volume of sphere
r=radius of sphere
η=viscosity of the fluid

Algorithm

1) Input the necessary parameters (density of liquid, sphere, viscosity of liquid, radius of sphere, tolerance and integration time step)(initial velocity of sphere is assumed to be 0)
2) The equation of motion is integrated using linear approximation to integral:

   $du/dt \simeq [u(t+\Delta t)-u(t)]/\Delta t$

   $u(t+\Delta t)=g\Delta t(1-\rho V/m) + u(t)[1+6\pi r\eta\Delta t/m]$

3) This is implemented using a loop incrementing the Δt each time till the error between $u(t+\Delta t)$ and $u(t)$ is less than the given tolerance.
4) The final u will be the terminal velocity
5) Analytical terminal velocity Is calculated by putting acceleration=0 in the equation of motion.
6) For a sphere it comes out to be: $vt=(\rho s-\rho l)*g*r^2*2/(9*n)$

Code

```
import sys, os.path

rs=float(input("denisty of solid sphere\n"))
r=float(input("radius of solid sphere\n"))
rl=float(input("denisty of liquid\n"))
n=float(input("visocity of liquid\n"))
t=float(input("Enter tolerance\n"))
d=float(input("Enter time difference\n"))
ae=100
vt0=0
while ae>t:
    vt=vt0+d*( (rs-rl)/rs*9.8-9/2*n*vt0/(r*r*rs))
    if vt!=0 :

      ae=abs(vt-vt0)
    vt0=vt

vt1=(rs-rl)*9.8*r*r*2/(9*n)
print('Terminal velocity using the numerical method:', vt)
print('Terminal velocity using the analytical method:', vt1)
print("% error using numeical method : ",abs((vt-vt1)*100/vt1))
```

Output

```
denisty of solid sphere
8050
radius of solid sphere
1
denisty of liquid
1000
visocity of liquid
1
Enter tolerance
0.0001
Enter time difference
0.01
Terminal velocity using the numerical method: 15335.444581786996
Terminal velocity using the analytical method: 15353.333333333334
% error using numeical method :  0.11651379643728299
```