

PA1

PROGRAMMING ASSIGNMENT 1 BME 121, FALL 2016

Due Fri Sep 23 at 4:30 pm

PROBLEM

Ultrasound imaging of blood vessels is difficult because the contrast between blood and surrounding tissue is low at ultrasound frequencies. One solution is to inject a chemical concoction which basically comprises air-filled microspheres that survive for a few minutes in the blood. If the so-called free-resonance frequency of these microspheres is near the frequency of the ultrasound transducer, they can have an apparent scattering cross section three orders of magnitude larger than their actual geometric cross section. This makes them (and thus the blood in which they are suspended) much more visible in the ultrasound image.

According to a 2005 paper¹ by Sassaroli and Hynynen, the free resonant frequency f_0 (in Hertz) of a microsphere of radius a_0 (in metres) can be determined by the equation

$$f_0 = \frac{1}{2\pi} \sqrt{\frac{1}{\rho (a_0)^2} \left(3\kappa P_0 + (3\kappa - 1) \frac{2\sigma}{a_0} \right)}$$

where ρ is the blood density (in kilograms per cubic metre), σ is the blood surface tension (in Newtons per metre), κ is the polytropic index (a dimensionless number related to thermodynamic equilibrium which here will be nearly one), and P_0 is the sum of ambient and blood-vessel pressures (in Pascals).

With values $P_0 = 108600$ Pa, $\rho = 1.09 \times 10^3$ kg/m³, $\sigma = 0.0643$ N/m, $\kappa = 1.0$, and $a_0 = 1 \times 10^{-6}$ m, the result of the calculation should be $f_0 = 3.68 \times 10^6$ Hz.

ASSIGNMENT

Write a C# static helper method which will receive P_0 , ρ , σ , κ , and a_0 as parameters and return f_0 as its result. Write a C# static main method which will prompt the user to input values for P_0 , ρ , σ , κ , and a_0 then call your helper method using the values provided and display the resulting resonant frequency.

For this question, include comments appropriate to the situation where your fellow programmers know C# and know the problem domain. Choose appropriate variable names and an appropriate method name. Use double types for all variables and for the method return type. Include units in all prompts and output. An example of what the program should look like when run is given below.

```
Windows PowerShell
PS C:\Users\Freeman\Desktop\pa1> dotnet run
Project pa1 (.NETCoreApp,Version=v1.0) was previously compiled. Skipping compilation.

Microsphere free resonant frequency calculator

Enter the following five parameters.
Ambient plus blood-vessel pressures (Pa): 108600
Blood density (kg/m^3): 1090
Blood surface tension (N/m): .0643
Polytropic index: 1
Microsphere radius (m): .000001

Free resonant frequency is 3.68e+006 Hz
PS C:\Users\Freeman\Desktop\pa1>
```

SUBMISSION

Name your C# program file as pa1.cs. Use Bme121.PA1 as your namespace identifier. Include the standard doc-comment block. Submit pa1.cs at the following url.

<https://georgefreeman.ca/fileuploader>

¹ E. Sassaroli and K. Hynynen, "Resonance frequency of microbubbles in small blood vessels: A numerical study," *Phys. Med. Biol.*, vol. 50, pp. 5293-5305, 2005.