<u>BME 505 Project:</u>

The goal of the project is for you to gain insight into pulsatile fluid dynamics, which is relevant to many physiological flow problems, including blood flow in the circulation, using simulations. A write up of the results is required, and details are below. You are allowed to work with a partner if you choose but are required to turn in your own report. Several assumptions will have to be made to simplify the problem, and these assumptions should be addressed in the write-up.

Part I of the project is writing code to simulate fully developed pulsatile flow of a Newtonian fluid in a rigid tube. Part II is using your code to explore the effects of Reynolds number and Womersley number on blood flow dynamics.

Part I

Write a Matlab (or other) program that calculates Reynolds number and Womersley number for steady, oscillatory, and pulsatile flow and plots:

i. Velocity profiles, v(r,t)
ii. Flow rate, Q(t)
iii. Wall shear stress, $\tau_{wall}(t)$

Part II

Use the code you have written to explore the effects of Reynolds number and Womersley number on blood flow dynamics including the shape of the velocity profile, the flow rate and the wall shear stresses. For the fluid, let $\rho = 1.06$ g/cm^3 and $\mu = 4$ cP.

For steady flow, consider **at least** two cases:

1. -dP/dz =46 dynes/cm^3 and R=0.65 cm
2. -dP/dz =100 dynes/cm^3 and R=0.30 cm

For oscillatory flow, consider **at least** two cases:

1. -dP/dz = 46 $\cos(2\pi t/T)$ dynes/cm^3 and R=0.65 cm
2. -dP/dz =100 $\cos(2\pi t/T)$ dynes/cm^3 and R=0.30 cm

For pulsatile flow with a driving pressure gradient of the form given below, consider **at least** two cases:

$$\frac{dP}{dx} = -C - D\sum_{n=1}^{10} C_n \cos\left(\frac{2n\pi t}{T} + \Phi_n\right)$$

1. C=50, D=10 dynes/cm^3 for R=0.65 cm
2. C=20, D=30 dynes/cm^3 for R=0.30 cm

where C_n and Φ_n are as given in the table to the right.

n	C_n	Φ_n (degrees)
1	7.58	-174
2	5.41	89
3	1.52	-22
4	0.52	-34
5	0.83	-127
6	0.69	135
7	0.26	152
8	0.54	44
9	0.27	-72
10	0.10	11

Write Up

Your write-up should include the following sections:

A. Introduction, including a brief description of the physiological relevance of the flow conditions and geometries investigated in this project.
B. Model and Analyses
    1. Assumptions and governing equations
    2. Analytical solutions
C. Results (must include figures with axes labeled and appropriate units!)
D. Discussion
    1. Implications of Reynolds number for blood flow velocity profiles and wall shear stresses
    2. Implications of Womersley number for blood flow velocity profiles and wall shear stresses
    3. Limitations of the approach
E. Conclusions
F. Appendix: Programming code with appropriate comments.