Biomedical Mechanical Energy Balance (MEB) Problem (version 1.0 CST)
BE-382, Winter '08-'09, Dr. C. S. Tritt & Dr. J. A. LaMack

Modify the "MEB Biomedical Problem Example" spreadsheet (available for download from the course website (http://people.msoe.edu/~tritt/be382/homework.html) to better represent blood infusion. The spreadsheet currently solves the flow rate of a liquid that is driven by gravity from an elevated bag through a length of tubing that contains a needle at the end. It is assumed that the static pressure is the same in the bag as it is at the exit of the needle. The cells in the spreadsheet contain a series of formulas representing equations that need to be solved simultaneously. This is accomplished by using the Solver in Excel to adjust the independent variable (the flow rate of blood) until the mechanical energy balance is satisfied (cell B22 is zero). See the notes below regarding the use of the Solver function.

Based on your knowledge of the mechanical energy balance, part of the challenge of this assignment will be for you to identify exactly how the balance is being implemented in the spreadsheet. At that point, you will be able to modify the solution.

Specifically, add a term representing energy losses in the fitting connecting the needle to the tubing and adjust the fluid properties to better reflect those of blood.

Fitting Losses

The energy loss term for the tubing-to-needle fitting is $w_{lost} = k_{fitting}\sqrt{N_{\mathrm{Re},mean}}$ where w_{lost} is the specific lost work (in J/kg), $k_{fitting}$ is an empirical lost coefficient (0.084 J/kg) and $N_{\mathrm{Re,mean}}$ is the geometric mean of the tubing and needle Reynolds numbers. The geometric mean is defined as the square root of the product of two values (in this case the two Reynolds numbers).

Blood Properties

Change the fluid density, ρ, to 1.06 g/cm^3 and the viscosity, μ, to 2.70 cp.

Final Results

Use your modified spreadsheet to make a plot of blood flow rate as a function of needle diameter. Find the flow rates for needle diameters ranging from 0.50 to 2.00 mm in increments of 0.25 mm. Keep the length of the needle constant at 1 ½ inches. Use an elevation change of 0.70 m. (Hint: my modified spreadsheet indicated that for a 1.00 mm diameter needle the flow rate would be about 60.3 ml/min.)

Submit your spreadsheet electronically. Be sure to professionally format your plot and place it on its own sheet. By professional format, I mean the plot should have both x and y grids, uniform numeric formats on each axis and be initialed and dated. Be sure your name(s) appears in the spreadsheet. You may work with up to one other person on this assignment and submit a single spreadsheet.

Due Date: Thursday, January 8 by 4:00 pm

Regarding the Excel Solver Add-In

Before beginning, you will need to make sure the Solver Add-In is installed for Excel on your computer. To check this, select the Data tab. Solver will appear as a button in the Analysis grouping. If you do not see it, use the following steps to install it. You may need to be on the MSOE network to do this.

- Click on the Microsoft Office Button, and then click Excel Options
- Click Add-Ins, and then in the Manage box, select Excel Add-Ins
- Click Go
- In the Add-Ins available box, select the Solver Add-In check box, and then click OK.
- After you load the Solver Add-In, the Solver command is available in the Analysis group in the Data tab.

To use the Solver, enter the formula for the cell that you would like to set equal to zero (B22) in the "Set Target Cell:" field. Select the "Value of:" radio button and make sure zero is entered in the field next to it. Enter the formula for the cell containing the adjustable parameter in the "By Changing Cells:" field. Select Solve. If an error occurs (indicating no solution could be found), you may need to enter a value of the adjustable parameter into its field that is closer its solution and try again.