Assignment 4: VBA

Date Due: February 27, 2017   Instructor: Trani

Problem 1

The equation to predict the drag (D) of a high-speed train moving at speed (v) is given by the formula:

$$D = \frac{1}{2}\rho v^2 A C_d$$

where: ρ is the density of air (1.225 kg/cu.meter at sea level conditions), A is the reference area of the high-speed train (in sq. meters) and C_d is a non-dimensional drag coefficient unique to each train. Typically, the value of C_d is derived empirically from wind tunnel tests. In the formula above the units of v are meters per second and the units of D are in Newtons (since drag is a force).

A modern high-speed train shown in Figure 1 has the following characteristics:

A = 6.7 square meters

C_d = 0.27 (dimensionless)

Figure 1. High-Speed Train (South Korea).

Task 1:

Create a VBA program to estimate the drag force on the high-speed train for a range of velocities ranging from 1 to 70 m/s. In your analysis we want to create an Excel interface as shown in Figure 2. Note that a run button is required to execute the code from within the Excel interface. The VBA code should write the header for velocity and drag in row 10 of the Excel spreadsheet (as shown). Show all your VBA code.

	A	B	C	D	E	F
1						
2	HS Train Drag Calculation			Formula D = 1/2 * rho * v^2 * A * Cd		
3	Programmer: A. Trani					
4	Date: 02/14/09					
5			Units			
6	Area	7.50	sq. meters	Calculation		
7	Cd	0.30	dim			
8	Density	1.225	kg/cu.meter			
9						
10	Velocity (m/s)	Drag (N)				
11	1	1.378125				
12	2	5.5125				
13	3	12.403125				
14	4	22.05				
15	5	34.453125				

Figure 2. Excel Interface for Task 1.

Task 2:

Add VBA code to Task 1 and calculate the power required to overcome the drag force. The power required is:

$$P = Dv = \frac{1}{2}\rho v^3 A C_d$$

The power required should be written in Column C next to the values of drag calculated in Task 1. What are the units of power? Show all your code.

Task 3:

Using the VBA code and Excel solution in Task 2, estimate the drag and power requirements for the same high-speed train in City with an elevation of 3,000 meters above sea level. At 3,000 meters, the value of atmospheric density is 0.905 kg/cu.meters. Compare the solution with Task 2 and comment.

Problem 2

Modify the drag and power calculation created in Problem 1 as follows:

Task 1:

Add three values in the Excel interface created in Task 2 of Problem 1 containing the low and high values of velocity and the step size of velocity to be used in the computations of drag and power. These values can be added in cells B9 (low velocity), B10 (high velocity) and B11 (step size). These values will be read by the VBA code. Then your code should use these values as the starting, ending points and the step size of the FOR loop used to calculate the values of drag and power and produce outputs as shown in Figure 3. Show the correct units for the problem.

	A	B	C
1			
2	HS Train Drag Calculation		
3	Programmer: A. Trani		
4	Date: 02/14/09		
5			Units
6	Area	7.50	sq. meters
7	Cd	0.30	dim
8	Density	1.225	kg/cu.meter
9	Low Speed	1	m/s
10	High Speed	80.00	m/s
11	Step size	1.00	m/s
12			
13	Velocity (m/s)	Drag (N)	Power ()
14	1	1.378125	1.378125

Figure 3. New Problem Interface in Excel.

Task 2:

Add calculations to the code created in Task 1 of this problem to estimate the power in horsepower (HP). The conversion of power from SI units to English units can be found at:

http://www.gordonengland.co.uk/conversion/power.htm

Write your power calculation in HP (called horsepower metric in the web site) in column D for every value of velocity entered in column A.

Estimate the horsepower requirement at 135 mph (typical cruise speed of the South Korean train).

Problem 3

Re-use the program created in Problem 2 to estimate the drag (D) and power (P) of a high-speed train (HST) moving at speed (v). Recall the HST has the following characteristics: A = 6.7 square meters and C_d = 0.27 (dimensionless).

Task 1:

Change the VBA code to include all the declarations of variables in the problem. Use the Option Explicit command and declare all numeric variables to be double precision.

Task 2:

Once completed Task 1, estimate the time benefit of using the Option Explicit in the VBA code. Measure the CPU time to perform the calculations using the "timer" function in VBA. Run your code 10 times by changing values of A and C_d = 0.27 (by up to 10% from the nominal values) to see the variations in CPU time. If necessary see the example in Notes 9.

Problem 4

a) Explain the benefits of using a Macro in Excel.

b) Take a recent homework problem in another class and explain how a Macro could help solve the same problem with distinct data sets. Be specific and show and example of hoe the Macro facilitates your work.