

## Assignment 4: VBA Programming

Date Due: February 12, 2024

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### Problem 1

A train engineer finds that the basic train resistance of a high-speed train (see Figure 1) to be:

$$R = A + BV + CV^2$$

Where:

$R$  is the basic train resistance in kiloNewtons

$V$  is the train speed in meters/second

$A$ ,  $B$ ,  $C$  are empirical constants derived from wind tunnel test. The values of  $A$ ,  $B$ ,  $C$  are 8.2, 0.107, and 0.0119, respectively.

- 1) **Create a public function in Excel/VBA** to estimate the value of the basic train resistance ( $R$ ) given a value of train speed ( $V$ ).
- 2) Apply the Excel function created above using a table of speeds ranging from 0 to 90 m/s.
- 3) Use Excel to make a plot of train resistance (y-axis) versus speed (x-axis). Label accordingly.



Figure 1. High-speed Train (Shinkansen 300 series). Source: Wikipedia.

## Problem 2

Table 1 provides the California Bearing Ratios of various types of Soils according to the Unified Soil Classification System (USCS).

Table 1. CRB Values for Typical Soils According to the Unified Soil Classification System (USCS).

Soil Type	CBR (dim)
Well-graded gravels	55
Poorly-graded gravels	45
Gravel-sand-silt	35
Clayey gravels	30
Well-graded sands	29
Silty sands	28
Clayey sands	13
Inorganic silts	12
Inorganic silty clay	5
Fine silty soils	9
Peat soil	4

Create a spreadsheet and associated VBA code to estimate the total pavement thickness (in inches) according to the empirical equation:

$$\text{Pavement Thickness (inches)} = \sqrt{\text{Load} / (8.1 * \text{CBR}) + \text{Area} / \pi}$$

Where:

Thickness\_inches is the total pavement thickness (in inches)

Load is the single-wheel equivalent load in pounds

Area is the contact area between the tire and the pavement (square inches)

CBR is the California Bearing Ratio (dim)

The following features are needed for the spreadsheet and code:

- i) The user can select the soil type via a **data validation drop down menu list** containing the names of the soil type (column 1 in Table 1).
- ii) The **VBA code reads the values of CBR (column 2 in Table 1) and estimates the pavement thickness**. This means Table 1 (both columns) must be inserted into the spreadsheet at a location of your choice. The VBA code reads the values of column 2 once the soil type is selected by the user.
- iii) The VBA code reads the soil type from the validation drop box and reads the value of CBR from the spreadsheet (Table 1).
- iv) The VBA code creates a table of pavement thickness solutions for 10 values of load ranging from 20,000 to 40,000 lbs. The table with pavement thickness solutions are shown on the spreadsheet. Use a contact area of 250 square inches in your analysis.
- v) Declare all program the variables using Option Explicit.

### Problem 3

A simple formula used in highway engineering to estimate the horizontal radius of a road is:

$$R = \frac{v^2}{g(e + f)}$$

Where:

$R$  is the road horizontal radius (in meters)

$v$  is the road design speed (m/s)

$g$  is the gravitational constant (9.81 m/s<sup>2</sup>)

$e$  is the superelevation rate of the road (%/100). For example, a road with a superelevation rate of 0.06 implies the road of inclined at a lateral slope of 0.06 meters for each one meter in horizontal distance (see . Typical values of  $e$  vary from 0 (no superelevation) to 0.10 (high superelevation).

$f$  is the lateral friction force coefficient developed between the vehicle tires and the pavement.

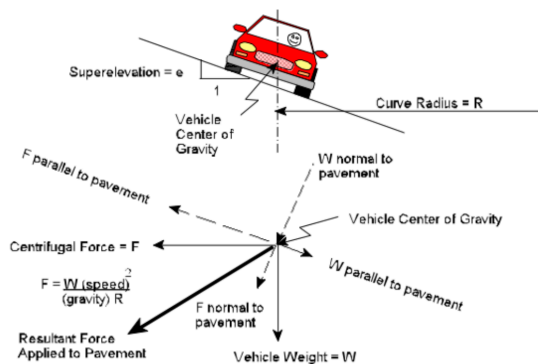


Figure 2. Road Superelevation Diagram. NYDOT.

The lateral friction force coefficient varies according to the table below. This means, at higher speeds, the car has less grip on the road to execute a turn.

Road Design Speed (m/s)	Lateral Friction Coefficient $f$ (dim)
8.34	0.17
16.70	0.15
25.00	0.12
33.34	0.09

A) Create a spreadsheet and associated VBA code to estimate the radius of the horizontal curve (in meters) according to the equation provided.

The following features are needed for the spreadsheet and code:

i) The user can select the value of superelevation ( $e$ ) from a drop-down list. Allowable values of  $e$  range from 0 to 0.10.

- ii) The user enters (directly on the spreadsheet) the value of speed (in meters/second) and the program calculates R in meters.
- iii) The VBA code estimates the value of lateral friction coefficient ( $f$ ) based on the value of speed entered. The estimation of  $f$  can be performed using the linear regression approximation of  $f$  versus speed ( $v$ ). The regression equation should be coded in VBA.

$$f = A + Bv$$

Where:

$A, B$  are two regression coefficients to be found using the Excel trend line of friction versus speed table data.

$v$  is the road design speed (m/s).

- iv) Declare all program the variables using Option Explicit.

B) Test the VBA code and the spreadsheet to find the horizontal radius (R) for different speeds ranging from 10 to 30 m/s. at steps of one m/s.