Determine the drag coefficient by fitting a polynomial to velocity-force data

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The magnitude of the aerodynamic drag force F_d on a moving automobile can be modeled by the equation:

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

where ρ is the density of the surrounding air, A is the *reference area* of the automobile, and C_d is a dimensionless constant called the *drag coefficient.* For a fixed car and air density, the equation can be simplified to:

$$F_d = \gamma v^2$$

where γ acts as an **effective drag coefficient** with units of $Force/Velocity^2$. In this problem, you will estimate the effective drag coefficient by fitting a polynomial to drag force data. The data file, VehicleDragData.csv, contains multiple force measurements taken at speeds from 15 to 150 km/h at increments of 5 km/h. Code has been provided to load the data into a table, **`dragData`,** with table variables **`Velocity`** and **`Force`**.

Complete the steps below to estimate γ by fitting a polynomial to the data using the **`polyfit`** function.

1. Create a column vector **`x`** corresponding to the **`Velocity`** values squared.
2. Use the **`polyfit`** function to *fit a linear polynomial* to the values in **`x`** and **`dragData.Force`,** and assign the result to the variable **`coeffs`**. (See the note below which outlines the reason for a linear fit with a transformed variable as opposed to a quadratic fit with the original variable).
3. Assign the linear coefficient in **`coeffs`** to the variable **`gamma`**.
4. Create the *column vector* **`vfit`** corresponding to the velocities in the data table: 15, 20, 25, ...,150.
5. Create the *column vector* **`Ffit`** containing estimated drag forces at the velocity values in **`vfit`**.

Note: By fitting a quadratic polynomial directly to the data using **`polyfit`**, we would include an unwanted linear and constant (bias) term, with the fitted model taking the form $F_d = \gamma v^2 + \beta v + \alpha$. While the constant term quickly becomes negligable, the effect of the linear term is significant at small to intermediate velocities. To fit a quadratic model *without* a linear term using **`polyfit`**, it is necessary to first *transform* the velocity data and fit a *linear model* of the form $F_d = \gamma x + \alpha$ using the new variable x, where $x = v^2$. (The constant coefficient (α) returned from **`polyfit`** can be safely ignored.)

```
dragData = readtable('VehicleDragData.csv','HeaderLines',3);
plot(dragData.Velocity,dragData.Force,'rx');
hold on;

x = dragData.Velocity.^2;
coeffs = polyfit(x,dragData.Force,1);
gamma = coeffs(1)
vfit = (15:5:150)';
Ffit = gamma*vfit.^2;
```

```
y1 = plot(vfit,Ffit,'b--','LineWidth',2);
hold off;
legend('Data','Fit');
xlabel('Velocity (km/h)');
ylabel('Drag Force (N)');
```