Speed of Sound Calculator

Contents

The formula used to calculate the speed of sound in air is derived from the principles of thermodynamics and fluid dynamics.

Formula

The speed of sound $\boldsymbol{c}$ is given by the following equation.

$$\boldsymbol{c} = \sqrt{\boldsymbol{\gamma}\,\boldsymbol{R}\,\boldsymbol{T}}$$

Variables

- $\boldsymbol{\gamma}$: Adiabatic index (also known as the ratio of specific heats). For air, this value is approximately 1.4.
- $\boldsymbol{R}$: Specific gas constant for dry air, which is 287.05 J/(kg·K).
- $\boldsymbol{T}$: Absolute temperature in Kelvin (K). To convert from Celsius to Kelvin, you add 273.15 to the Celsius temperature.

Explanation

- **Adiabatic Index ($\boldsymbol{\gamma}$)**: This is the ratio of the specific heat at constant pressure ($\boldsymbol{C_p}$) to the specific heat at constant volume ($\boldsymbol{C_v}$). It reflects how much the air resists compression.

- **Specific Gas Constant (R))**: This constant is specific to dry air and relates the energy per unit mass per degree of temperature.
- **Temperature (T)**: The temperature must be in Kelvin for the formula to work correctly. Temperature affects the speed of sound because higher temperatures increase the energy of the air molecules, making sound travel faster.
- **Lapse Rate**: The temperature typically decreases with altitude at a standard lapse rate of about 0.0065 Kelvin per meter. This is a simplified model to account for the change in temperature with altitude.

Assignment 1: Speed of Sound

1. Create a new MATLAB script named **SpeedOfSoundCalculator.m**
2. Define a function named **speedOfSound**
3. **Input Parameters**: The function should take two inputs.
    a. Altitude (in meters)
    b. Temperature (in Celsius at sea level)
4. Convert Celsius to Kelvin.
5. Adjust for altitude.
6. Calculate the speed of sound.
7. **Output**: The function should return the speed of sound (in meters per second).
    a. **Hint**: Use the sqrt function to calculate the square root.

main program

1. Prompt the user to input the altitude and temperature.
2. Call the **speedOfSound** function with the user inputs as arguments.
3. Display the result in a formatted manner.
    a. **Hint**: Use the fprintf function to format and display the output.

Example run:

```
Enter the altitude in meters: 1000
Enter sea level temperature in Celsius: 15
             Altitude: 1000.00 meters
Sea level temperature: 15.00°C
       Speed of sound: 336.43 m/s.
```

Tutorial 1: How to Use Arrayfun

To use our speedOfSound function to create a plot, we need to apply the function to each element of two arrays (vectors).

arrayfun applies a function to each element of an array and returns an array of the same size, where each element is the result of applying the function to the corresponding element of the input array.

Syntax

```
outputArray = arrayfun(func, inputArray)
```

- **func**: The function handle to apply to each element of the array A.
- **inputArray**: The input array.
- **outputArray**: The output array, where each element is the result of applying func to the corresponding element of inputArray.

Using arrayfun with Custom Functions

You can use arrayfun with custom functions defined in separate files or at the top of the file.

1. **Define a Custom Function**:
   - Create a function named **myFunction**
   - Call this function from the **SpeedOfSoundCalculator** file.

```
%% Arrayfun example
clc
function y = myFunction(x)
    y = x^3 + 2*x^2 + x;
end
```

2. **Create the Input Array**:
   - Define an array of numbers.

```
inputArray = [1, 2, 3, 4, 5];
```

3. **Apply arrayfun**:
    - Use arrayfun to apply myFunction to each element of inputArray.

```
outputArray = arrayfun(@myFunction, inputArray);
```

4. **Display the Result**:
    - The output array outputArray will contain the results of applying myFunction to each element of inputArray.

```
disp(outputArray);
```

Example run:

```
4     18     48    100    180
```

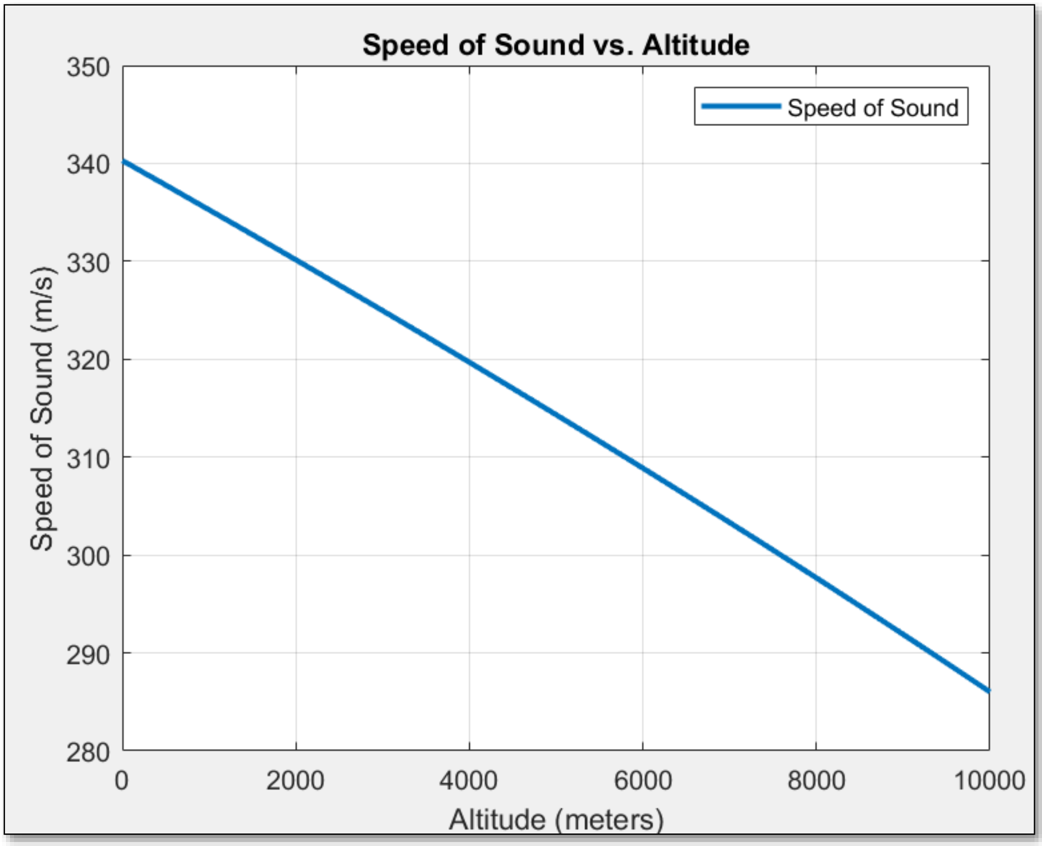
Assignment 2: Plotting the Speed of Sound vs. Altitude

At the end of our current program, let's add a section that calculates and plots the speed of sound vs altitude.

1. Define a vector using linspace to define values 0 to 10,000 meters with 100 points
2. Define a vector using linspace to define values 15°C at 0 meters to -4.6°C at 10,000 meters. These values are from the Internation Standard Atmosphere (ISA).
3. Here is the function to calculate the speed of sound for each altitude for a fixed temperature.

```
% Use arrayfun to apply the speedOfSound function to each element
% in the altitudes and temperatures array
% The anonymous function @(altitude) speedOfSound(altitude, temperature)
% takes each altitude (altitude) and calculates the speed of sound
% at that altitude for the given temperature
speeds = arrayfun(@(altitude, temp) speedOfSound(altitude, temp), altitudes, temperatures);
```

4. Plot the results of the speed of sound against altitude.



Assignment Submission

1. Submit properly named and commented script files.
2. Attach a screenshot of the Command Window showing the successful execution of each script.
3. Attach all to the assignment in Blackboard.