EML 3303C and EAS 3800C

Mechanical and Aerospace Engineering Measurements

Jet Engine Virtual laboratory

(Solo assignment – Extra Credit worth 1 Grade Percentage Point)

I) Objectives:

1. Practice virtual testing of jet engine performance (by measuring thrust, fuel consumption, and efficiency) under different operating conditions.
2. Gain familiarity with jet engine components and their respective function.
3. Background:

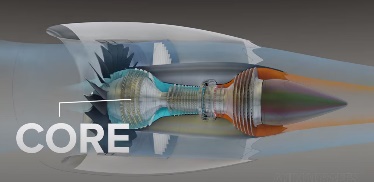
Jet engines are used to generate power and consist of many components including:

* Diffuser
* Compressor
* Combustion chamber
* Turbine
* Nozzle

(More information about how jet engines work may be found at [this link](https://www.youtube.com/watch?v=L24Wf0VlTE0))

In this experiment, variation in the compressor pressure ratio (CPR) and bypass ratio (BPR) are used to analyze the effects on the jet engine’s performance:

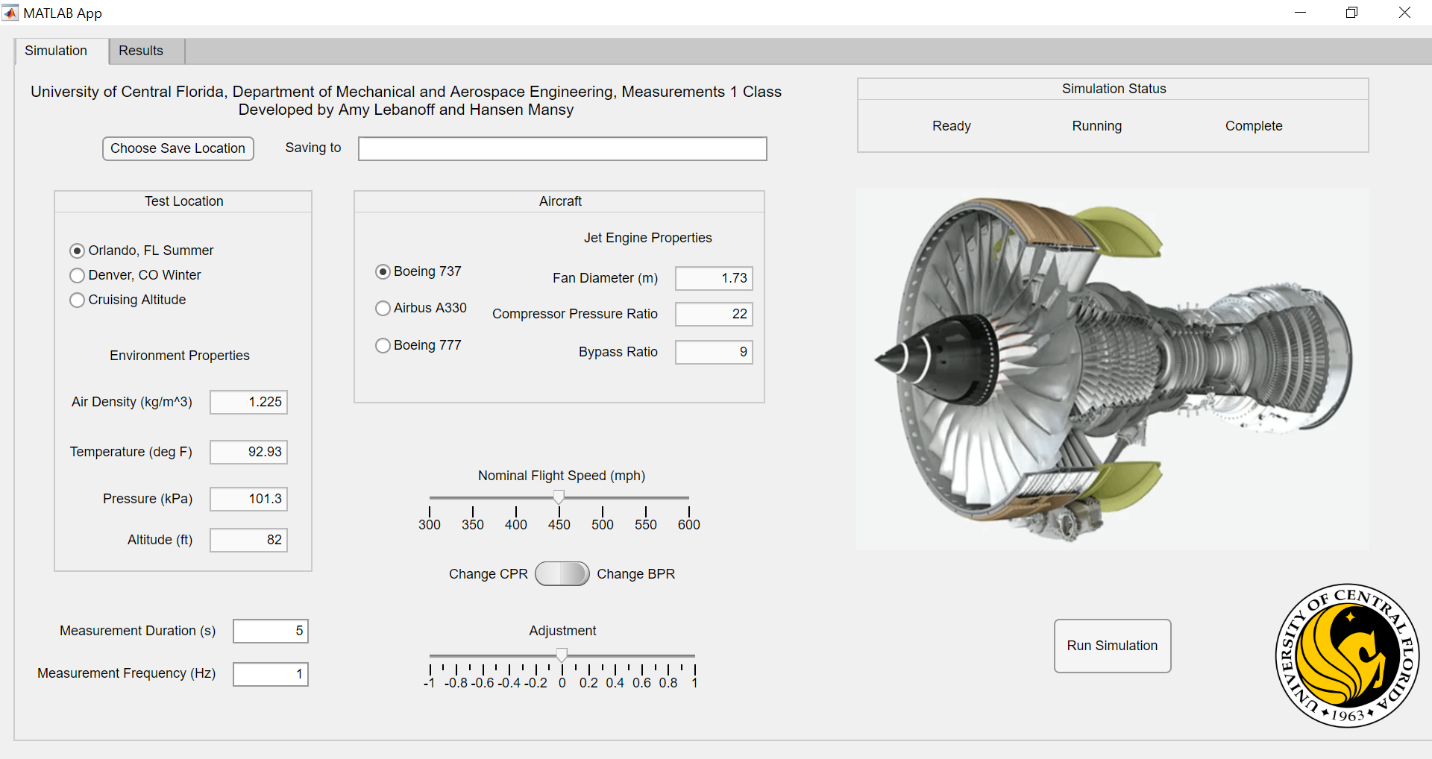
* CPR is the ratio of the air pressure exiting the compressor to the air pressure entering the compressor (Pout, compressor/Pin, compressor). As the compressor does work on the airflow, the air pressure increased at air flows through the compressor. Hence, CPR is always greater than 1.
* BPR is the ratio of the mass flow rate of air that bypasses the engine core to the mass flow rate of the air that enters the engine core . This factor comes into play when designing jet engines and depends on their overall use. Commercial airlines typically use a high BPR.



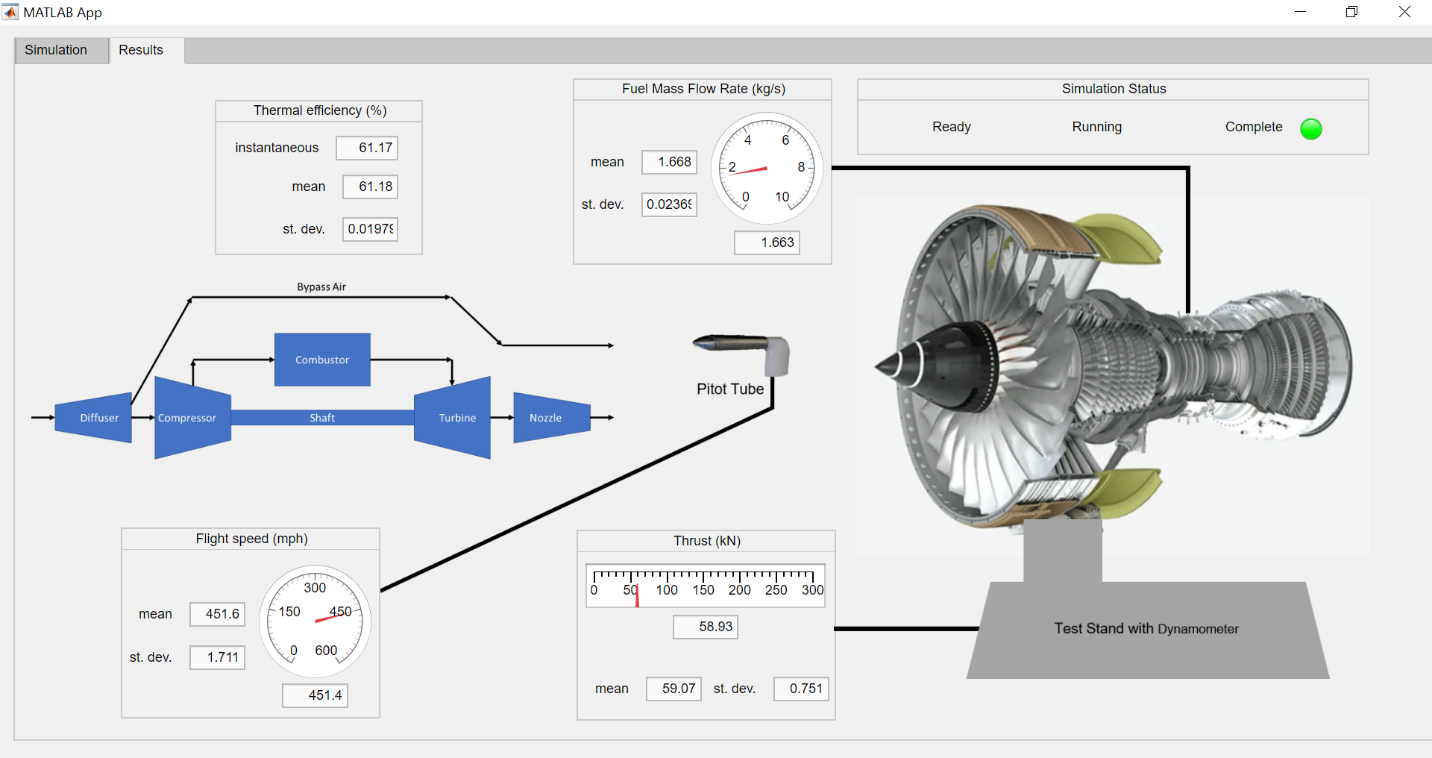
**BYPASS**

1. Apparatus:

An application that you can run on your computer (see **Figure 1**)



**Figure 1a: MATLAB application, Simulation panel**



**Figure 1b: MATLAB application, Results panel**

1. Procedure:

Your team is assigned an aircraft and an operating location (see **Table 1**). All members of your team will have the same aircraft and location while individual team members have their own flight speed according to their last name alphabetical order in their team. The speeds are in the following order: 350, 400, 450, 500, or 550 mph. For example, the first member of the team will run measurements at the first speed and so on. Since this is a solo assignment, the student is only responsible for the speed assigned to her/him.

**Table 1: Aircraft and Location Combinations**

|  |  |  |
| --- | --- | --- |
| **Team** | **Aircraft** | **Location** |
| **1** | Boeing 737 | Orlando, FL |
| **2** | Airbus A330 | Orlando, FL |
| **3** | Boeing 777 | Orlando, FL |
| **4** | Boeing 737 | Cruising Altitude |
| **5** | Airbus A330 | Cruising Altitude |
| **6** | Boeing 777 | Cruising Altitude |

**IV.A Preparing to run the MATLAB application.**

This section describes how to prepare to run the application. See [this video](https://youtu.be/pHq15CqnURA) for a demonstration of the application’s features.

1. Download the MATLAB application (jet\_engine\_app.exe) from Webcourses.
2. Installation may involve two stages. Double-click the jet\_engine\_app icon to begin the first installation for MATLAB Runtime which will run the app.
3. Once the window says “Installation Completed Successfully,” click “Finish.”
4. Double-click the jet\_engine\_v3 icon again to begin the second installation for the Jet Engine app itself.
5. Select the box to “Add a shortcut to the desktop.”
6. Once installation is complete, open the app from the desktop jet\_engine\_v3 icon.
7. Click “Choose Save Location,” and navigate to the folder where you would like to save your data. Click “OK.”

**IV.B Setting values that will remain constant for all trials**

1. On the Simulation panel, select the appropriate “Test Location” for your team (see **Table 1**). This will set the appropriate ambient temperature and pressure for that location.
2. Select the appropriate “Aircraft” for your team. This selection sets the fan diameter, compressor pressure ratio, and bypass ratio at the typical design conditions. This information is already included in the application but is provided in **Table 2** for your knowledge.
3. Below the “Aircraft” selection, use the slider to set the “Nominal Flight Speed” as determined by alphabetical order of your last name in the team. Only use the speed assigned to you.
4. In the bottom left corner, set the “Measurement Duration” to 15 s and “Measurement Frequency” to 2 Hz.

**Table 2: Aircraft Characteristics**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Aircraft | Engine | Fan Diameter (m) | Pressure Ratio | Bypass Ratio |
| Boeing 737 | CFM LEAP-1B | 1.73 | 22:1 | 9:1 |
| Airbus A330 | CF6-80E | 2.19 | 33.6:1 | 5:1 |
| Boeing 777 | PW4000 | 2.85 | 34.2:1 | 6.4:1 |

**IV.C.1 Fix BPR and vary CPR**

1. On the Simulation panel, set the rocker switch to “Change CPR.” Confirm this selection by moving the “Adjustment” slider and watching the “Compressor Pressure Ratio” value change.
2. Now, you are going to change CPR around its design value and save the measured thrust, fuel mass flow rate, and thermal efficiency.
3. Use the “Adjustment” slider to choose 10 CPR values in the available range of the slider.
4. Run the simulation (at each slider setting) by clicking “Run Simulation.” The data will automatically be saved as an Excel file in the location you selected earlier.
5. Open the saved file in Excel to ensure data was properly saved and familiarize yourself with the data included. The three measured variables (mean and standard deviation) will be in the bottom row of the file.
6. Choose a new setting for the “Adjustment” slider while leaving all other settings unchanged.
7. Repeat steps 4-6 until you have 10 saved files, each with a different CPR.

**IV.C.2 Fix CPR and vary BPR**

1. On the Simulation panel, set the rocker switch to “Change BPR.” Confirm this selection by moving the “Adjustment” slider and watching the “Bypass Ratio” value change.
2. Now, you are going to change BPR around its design value and save the measured thrust, fuel mass flow rate, and thermal efficiency.
3. Use the “Adjustment” slider to choose 10 BPR values in the available range of the slider.
4. Run the simulation (at each slider setting) by clicking “Run Simulation.” The data will automatically be saved as an Excel file in the location you selected earlier.
5. Open the saved file in Excel to ensure data was properly saved and familiarize yourself with the data included. The three measured variables (mean and standard deviation) will be in the bottom row of the file.
6. Choose a new setting for the “Adjustment” slider while leaving all other settings unchanged.
7. Repeat steps 4-6 until you have 10 saved files, each with a different BPR.

**IV.D Plotting the results**

For each run, the application saves an Excel file with the chosen variables and measured data. Among other values, this includes the mean and standard deviation for the three dependent variables: thrust, fuel mass flow rate, and thermal efficiency. The independent variables (compressor pressure ratio (CPR) and bypass ratio (BPR)) are also included.

You will create six separate plots total: three showing the influence of CPR on jet engine performance, and 3 showing the influence of BPR on jet engine performance. Be sure to include plot titles, axis labels, and variable units. The figures should be such that:

* [1 point] Figure 1: the mean thrust (y-axis) as a function of CPR (x-axis)
* [1 point] Figure 2: the mean fuel mass flow rate as a function of CPR
* [1 point] Figure 3: the mean thermal efficiency as a function of CPR
* [1 point] Figure 4: the mean thrust as a function of BPR
* [1 point] Figure 5: the mean fuel mass flow rate as a function of BPR
* [1 point] Figure 6: the mean thermal efficiency as a function of BPR

Hint 1: Each figure will contain 10 operating conditions. Since each condition is saved in a separate file, it is advisable that you combine the 10 different CPR conditions in one spreadsheet and the 10 different BPR conditions in another spreadsheet before generating these figures.

Hint 2: You are not required to plot the standard deviation of the measured quantities.

**IV.E Submitting the assignment**

Combine all six figures in one PDF document and upload to Webcourses.