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Vehicle Testing laboratory Assignment-2

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TITLE:

DRIVE CYCLES AND FUEL ECONOMY TEST

Executive Summary:

- Plot velocity vs. time for the drive cycle you performed. On the same plot, plot the acceptable upper and lower limit of the drive cycle and on same plot own velocity vs time trace.
- To conclude the valid of test and calculate the minimum rms error in given "t" seconds and selecting the minimum value.
- For fuel economy we need to plot fuel flowrate vs time for drive cycle.as the signal is noisy we need to use butter forth filter and determine the filter strength
- To calculate the fuel economy of drive cycle by using two seconds moving window an calculate the instantaneous fuel economy through drive cycle as function of time.
- To determine the sufficient points in y- axis plot and change driving style to increase instantaneous economy within valid test bounds.
- To determine the rank of fuel economy and calculate everyone's fuel economy and validity.

INTRODUCTION:

Purpose of testing:

- For typical driving conditions the vehicles used to be tested over specific driving cycles.
- The manufactures test different vehicles to meet their standards set by cycles and one up the competitors.
- The main purpose of testing of a vehicle is to survive long in the market and to provide a comfortable, safe and high-performance vehicle to customers that work efficiently for longer period.
- The manufactures during testing they need to check the quality, durability, technologies function properly throughout their working life.
- During testing of a vehicle, the engineers must think highly innovative applications to test the vehicle to ensure the performance in highly effective and modern way.
- The test engineers need to react accordingly with the growing rate of innovations in industry.
- To test and evaluate advanced vehicle technologies intended to advance vehicle efficiency and reduce the consumption of petroleum.
- They mainly help in refining the quality of the vehicles and also, help to reduce down the vibrations and the noise in the vehicle while enhancing overall performance of the products to serve the best in the market to customers.

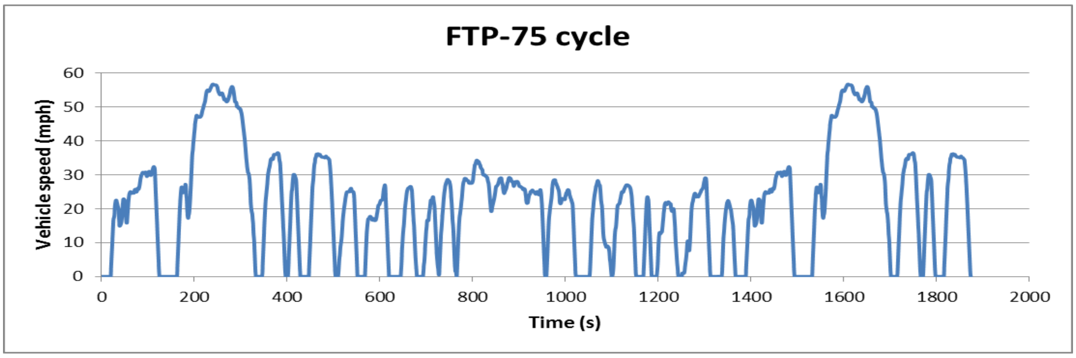
General Information About Topic:

- The vehicle testing is to refine the quality of the vehicles, to reduce vibration and noise, to improve efficiency, quality, performance of the vehicle. The vehicle is needed to test under different road conditions under different drive cycles for better improvement of the vehicle. There are specific vehicles that are needed to be tested under standard conditions. The drive cycles used across world-wide are

a) U.S drive cycle –

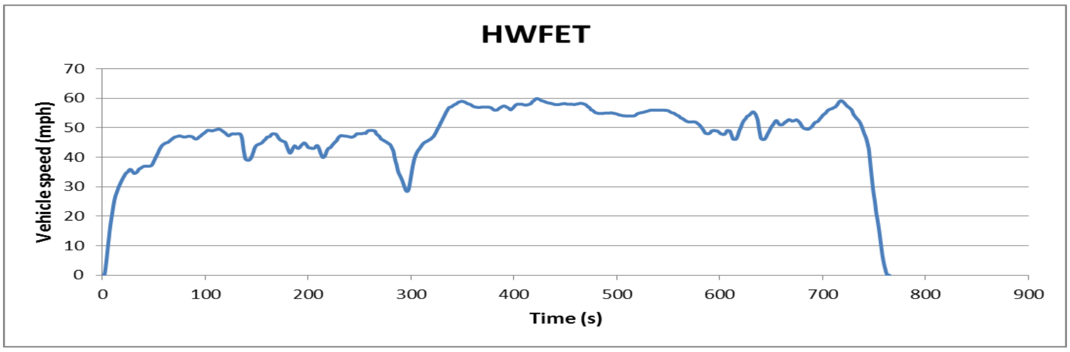
- **FTP-75 Cycle**

  - The FTP cycle was created by US EPA (Environmental Protection Agency) to represent a commuting cycle with a part of urban driving including frequent stops and a part of highway driving.



- **Highway Fuel Economy Test Cycle:**

  - The highway fuel economy test cycle (HWFET) is used for to know the economy of the fuel over highway driving cycle.

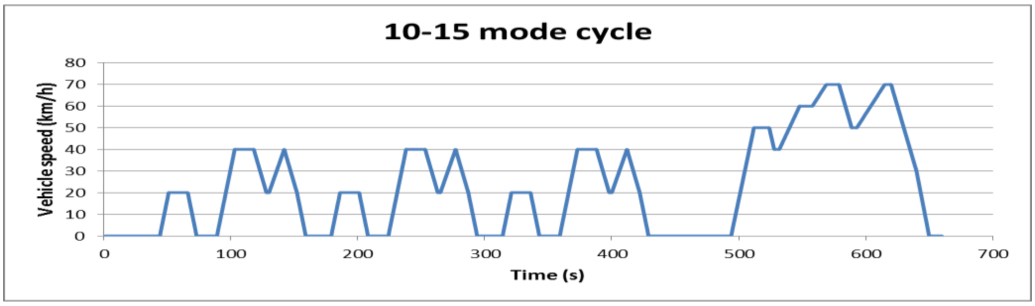


  - The main characteristics of the highway fuel economy test cycle are

b) Japanese driving cycle:

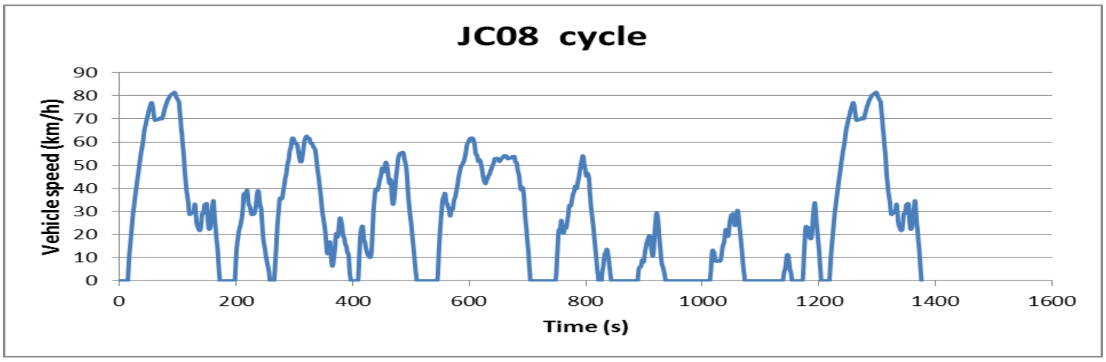
- **The 10-15 mode driving cycles:**

  - The Japanese driving cycle is used mainly in determining the fuel consumption and emissions from the vehicle. This cycle has disadvantages as the NEDC.



❖ **JC08 Cycle:**

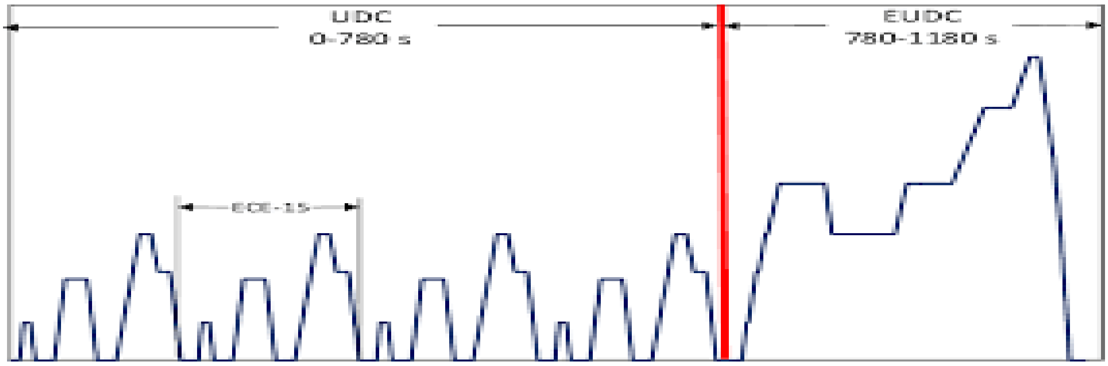
- When the Japanese authorities and manufactures decided when 10-15 drive cycle has NEDC disadvantage then switched JC08 Cycle. Also, the cycle is performed in both cold and warm start with strong accelerations and de-accelerations.



c) European drive cycle:

❖ **NEDC drive cycle**:

- The NEDC drive cycle is used to know the emission levels of vehicles engines and fuel economy in passenger vehicles.



Materials and Methods:

Materials:

- The EPA National Vehicle and fuel emissions laboratory:

  - The NVFEL is used for evaluation and certify the vehicle. Here, the vehicle is tested in a dynamometer test cell and the driver in the vehicle operates the vehicle by following different driving cycles. For the exhaust a hose is connected to the tail pipe. To collect engine exhaust. In addition, the carbon is measured to calculate the amount of fuel burned and other pollutants are measured by gas analyzers weighted in a special clean room. Few vehicles may differ (electric vehicles).

Methods:

- The two types of tests are conducted during driving of the vehicle-
  a) City Test
  b) Highway Test

a. City Test:

- In city test, the vehicle is accelerated to the given distance. As it is short segment driveway test, the vehicle needs to stop and accelerate according to road conditions. The trip lasts for 23 minutes with 17 stops in it. Most of the time its spent on idling time. The city test has many stops and breaks in the freeway.

b. Highway Test:

- In highway test, it's a long test where the driver needs to drive the vehicle for 10 miles of 48mph. There are no stops and breaks on the freeway. The very little idling takes place during driving the vehicle.

c. During driving the vehicle, the wind drags, and the inertia exerts for a dynamometer.
d. Butterworth filters are the type of signal processing filter considered to have as flat frequency response as possible with no ripples in the pass-band and zero roll off response in the stop-band.
e. It's one of the most commonly used digital filters in motion analysis and in audio circuits.

   Syntax of Butterworth Filter in MATLAB:

   [y, x] = butter (n, F)

   [y, x] = butter (n, F, Ftype)

   Where,

   - [y, x]: butter (n, F) is used to return the coefficients of transfer function for an nth-order digital Butterworth filter. This is a lowpass filter with a normalized cut off frequency of F.
   - [y, x]: butter (n, F, F-type) is used to design any of the highpass, lowpass, bandpass, bandstop Butterworth filter. The type of filter designed depends on cut off frequency and on Ftype argument.

Results and Discussions:

a) The test conducted is valid.

b) The minimum root mean square error for "t" seconds is 2.587834061040416.

References:

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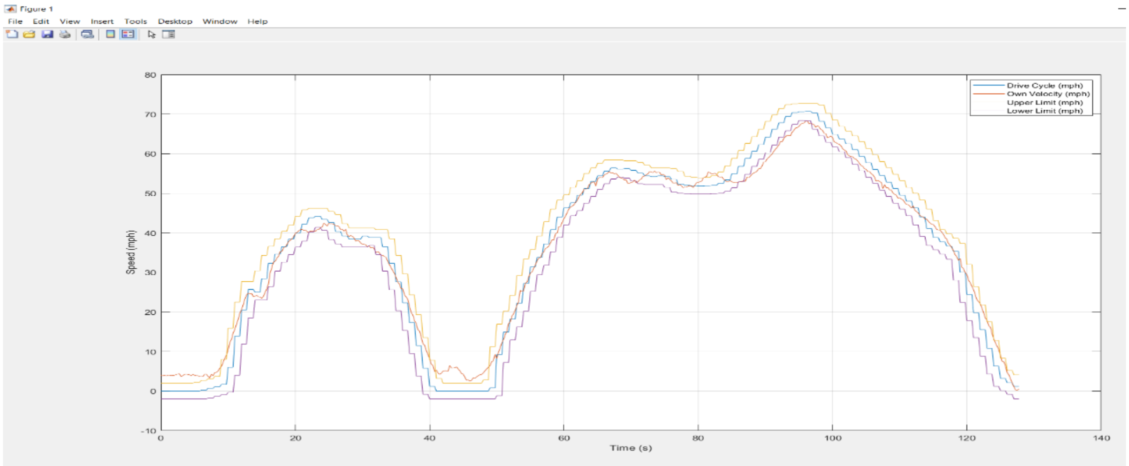
Appendix:

Task 1:

Graph:



a) MATLAB script;

```
data=readtable('Siddharth2.xlsx');
time=data{:,1};

figure
drive_cycle=data{:,3};
plot(time,drive_cycle)
hold on
velocity=data{:,2};
plot(time,velocity)

xlabel('Time (s)')
ylabel('Speed (mph)')
grid on

speed_max=data{:,4};
plot(time,speed_max)

speed_min=data{:,5};
plot(time,speed_min)

legend('Drive Cycle (mph)','Own Velocity (mph)','Upper Limit (mph)','Lower Limit (mph)')
hold off

%Root mean square for the test
RMSE = sqrt(mean((drive_cycle - velocity).^2));
disp(sprintf('Root mean square of the test speed is: %d ',RMSE))
```

```
%Minimum Root mean squared error for a 60sec window
first=1.0000;
second=60.0000;
i=find(time==first);
j=find(time==second);
RMSE_array=[];
index=1;
while(second<length(time))

    drive_cycle_array=drive_cycle(i:j);
    velocity_array=velocity(i:j);
    RMSE_array(index) = sqrt(mean((drive_cycle_array - velocity_array).^2));
    index=index+1;

    first=first+1;
    second=second+1;
    i=find(time==first);
    j=find(time==second);
end

Minimum_RMSE_array=min(RMSE_array);
disp(sprintf('Minimum Root mean squared error for a 60sec window is: %d
',Minimum_RMSE_array))
```

a) The test conducted is valid.
b) The minimum root mean square error for “t” seconds is 2.587834061040416

Task-2

For task 2 – a and c Graph:
Figure-1:

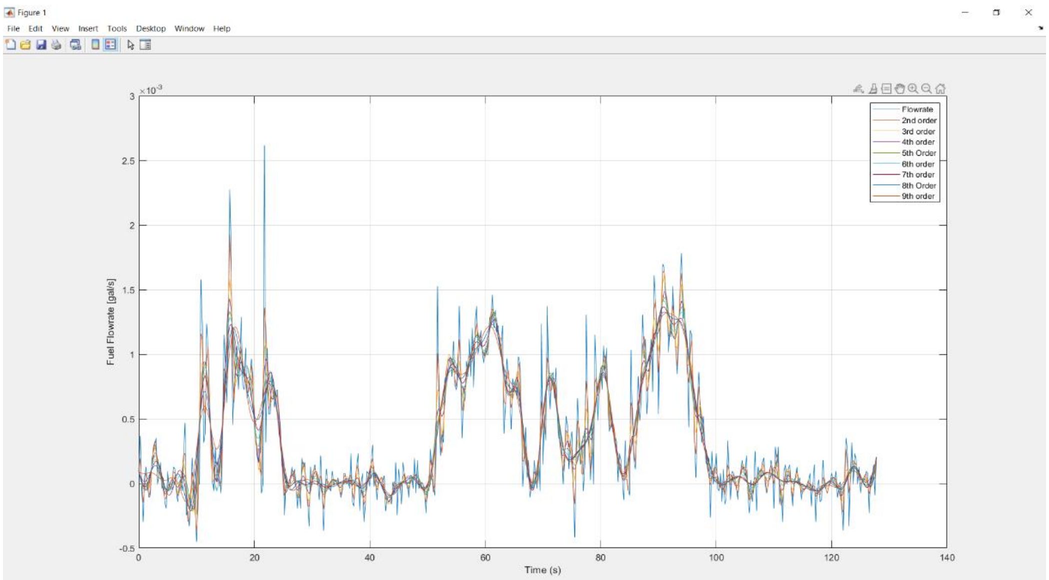
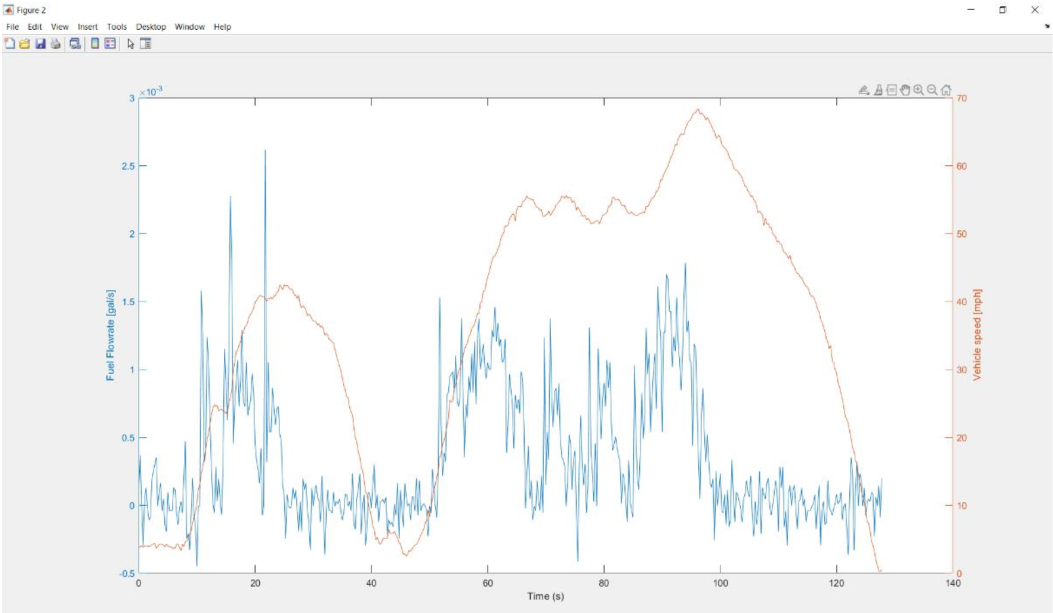


Figure-2:

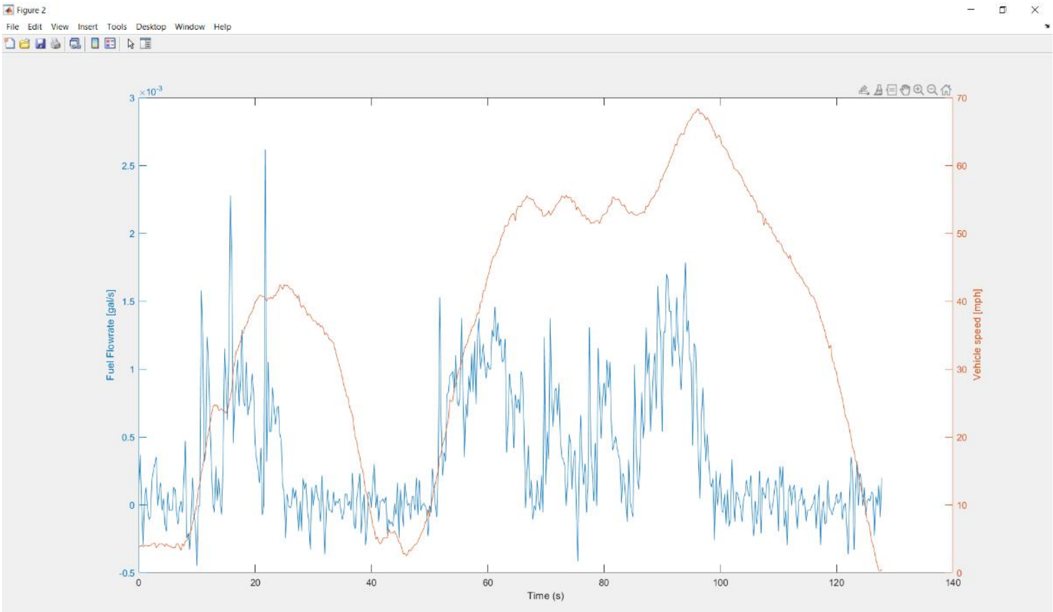


MATLAB Script

a) graph flow rate vs time for drive cycle using Butterforth with strengths
b) To create the dual y-axis with vehicle speed.

```
data=readtable('Siddharth2.xlsx');
time=data{:,1};
figure(1)
flow_rate=data{:,6};
plot(time,flow_rate)
xlabel('Time (s)')
ylabel('Fuel Flowrate [gal/s]')
grid on
hold on


n = 2:1:9;
wn = 1./n;

for i=1:length(n)
   [b,a] = butter(n(i),wn(i));
   flow_rate_filtered=filtfilt(b,a,flow_rate);
   plot(time,flow_rate_filtered)

end
legend('Flowrate','2nd order', '3rd order', '4th order', '5th Order', '6th order','7th order', '8th Order', '9th order')
```

```
hold off

figure(2)
xlabel('Time (s)')

yyaxis left
plot(time,flow_rate)
ylabel('Fuel Flowrate [gal/s]')
hold on

velocity=data{:,2};
yyaxis right
plot(time,velocity)
ylabel('Vehicle speed [mph]')
```



b. Instantaneous velocity =B2*60/F2 has been calculated in the procedure.

d. Number of seconds that are not valid for each student are

- Pradyuman- 8 seconds
- Abdullah Kose- 10.5 seconds
- Sai Nikhil M- 14.25 seconds
- Asit – 15seconds
- Dharmaraj – 15.782 seconds
- Jose – 15.75 seconds
- Siddharth thorat- 36 seconds
- Ruhee.D- 44 seconds
- Preetham.T- 46 seconds