Team: P19231
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P19231 Test Plans

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Collection Data & Data Verification:

1. Manual Transmission Data Collection

1.1 Hill Lower RPM/Velocity Test

1.1.1 Test Description:

- Student A will drive the 2012 Chevrolet Cruze from a 0-degree incline position and will achieve designated speed value and specified gear, as specified in **Table 1**, before going up a hill. Student A will attempt to maintain constant speed as the vehicle goes up the hill.
- Test to be repeated & completed on different hills with measured inclination, 3-5 different value slopes.
- Test will be repeated following the outline in **Table 1**.

1.1.2 Test Goal:

- The goal of the test is to determine the lower rpm/velocity value the car can maintain going up the hill.

1.2 Uphill Start Baseline RPM Test

1.2.1 Test Description:

- Student A will start with the 2012 Chevrolet Cruze stopped at the base of a hill. Student A will attempt to go up the hill without touching the accelerator pedal. If there is a need to press the gas pedal, press as lightly and slowly as possible until the car achieves motion. Repeat this test 3-5 times to achieve an average of results.
- Student A will then drive the 2012 Chevrolet Cruze up the hill using clutch and gas pedal to simulate a real uphill start. Repeat this test 3-5 times to achieve an average of results.
- Student A will repeat these tests with erroneous clutch & gas pedal timing to simulate car rolling back, stalling conditions & jarring.
- Test to be repeated & completed on different hills with measure inclination, 3-5 different value hills.

1.2.2 Test Goal:

- The goal of the test is to collect the data needed to identify the 2012 Chevrolet Cruze's minimum RPMs to move up in a specific hill. This test will also gather data on car behavior (RPM, Velocity & Clutch Position) of normal uphill, rolling back and stalling conditions.

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1.3 Changing Gears Uphill RPM Test

1.3.1 Test Description:

- Student A will drive the 2012 Chevrolet Cruze at a constant RPM value into a known degree elevation hill. Maintaining the current RPM, shift into next sequential gear.
- Record RPM data for this test.

1.3.2 Test Goal:

- Collect data for the 2012 Chevrolet Cruze's RPMs variance when changing gears uphill.

1.4 Clutch Riding RPM Variance Test

1.4.1 Test Description:

- Student A will be driving the 2012 Chevrolet Cruze while Clutch Riding (having the clutch partially engaged when the vehicle is in motion). This test will be completed in short intervals (> 5 mins) to prevent permanent damage to the clutch. Repeat the test 10-15 times.
- Record the RPM data from the interval testing.

1.4.2 Test Goal

- Collect data for the RPMs variance when Clutch Driving.

1.5 Gentle Driving Test

1.5.1 Test Description:

- Start the 2012 Chevrolet Cruze. At a standstill, shift into 1st gear, gently release the clutch, and start moving. Accelerate at a gentle pace. Short-shift into higher gears when accelerating. Do not exceed 40% throttle input and do not exceed 2500RPM. Drive along side streets, limited highway driving. Cruise at or below 1500RPM.
- Repeat for 1 hour of driving.

1.5.2 Test Goal:

- Data collection to quantify the shift pattern for a typical, easy-going driving style.

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1.6 Aggressive Driving Test

1.6.1 Test Description:

- Start the 2012 Chevrolet Cruze. At a standstill, shift into 1st, release the clutch and start moving. Accelerate at a brisk pace. Carry out the RPMs to approximately 4000RPM when accelerating in lower gears. Get up to traffic speed quickly. Drive along main roads, incorporate highway driving as well. (**DO NOT EXCEED THE SPEED LIMIT**).
- Repeat for 1 hour of driving.

1.6.2 Test Goal:

- Data collection to quantify the shift pattern for a typical “aggressive” driving style.

1.7 Late Shifting Test

1.7.1 Test Description:

- Student A will be driving the 2012 Chevrolet Cruze conservatively (<2500RPMs) but will be shifting late. Drive for 1 hour.
- Shifting late is defined as releasing the clutch completely before touching the gas pedal.

1.7.2 Test Goal:

- Collect data on the 2012 Chevrolet Cruze’s RPMs of a poorly timed shift.

1.8 Early Shifting Test

1.8.1 Test Description:

- Student A will be driving conservatively (<2500RPMs) but will be shifting early. Drive for 1 hour.
- Shifting early is defined as pressing on the gas pedal before the full release of the clutch.

1.8.2 Test Goal:

- Collect data on the 2012 Chevrolet Cruze’s RPMs of a poorly timed shift.

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1.9 Rolling Stop-Start Test

1.9.1 Test Description:

- Start the 2012 Chevrolet Cruze. Begin driving along a side street.
- Approach a stop sign and apply the brake to slow down.
- Lower the current gear to 2nd at least 200ft before the stop sign.
- Fully depress the clutch and coast at ~5mph until reaching the stop line.
- Release the clutch, still in 2nd gear, and begin accelerating again.
- Repeat 10 times for accuracy.
- This test will be repeated following **Table 2**.

1.9.2 Test Goals:

- Determine the RPM vs speed patterns for low-speed stop-start conditions.

1.10 Early Release Stall Test

1.10.1 Test Description

- Start the 2012 Chevrolet Cruze. At a standstill, shift into 1st and quickly release the clutch without providing any throttle input.
- Re-start the car and repeat for 2nd and reverse.

1.10.2 Test Goal

- Determine how quickly one must release the clutch to induce stalling conditions.

1.11 Complete Stop Stall Test

1.11.1 Test Description

- Start the 2012 Chevrolet Cruze and start moving. While the car is in motion, press the brake to slow the car down. Do not press the clutch or shift out of the current gear, and allow the car to stall.
- Repeat the stalling condition for reverse and each gear.

1.11.2 Test Goal

- Log the RPM behavior during stall conditions (min. RPM achieved before stall condition).

1.12 Calibration RPM-to-Velocity Test

1.12.1 Test Description

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- Connect the data logging device to the 2012 Chevrolet Cruze's OBD-II port
- Student A will start on level ground and an open road with the car stopped.
- Student A will engage the clutch and shift into 1st gear, slowly accelerating the car to redline in 1st gear.
- After reaching redline, shift up into 2nd gear and let the RPMs drop until near-idle RPM is reached (prevent stalling).
- Repeat this procedure for each of the remaining gears. For higher gears where speeds at higher RPM are unreasonable (and illegal), only go up to ~3500 RPM or the legal speed limit, whichever occurs first.
- Repeat again from a standstill for reverse gear.
- Repeat entire test at least 3-5 times for accuracy.

1.12.2 Test Goals

- To gain a direct mapping/relationship between the RPM of each gear and the associated vehicle speed.

1.13 Proper Gear Skipping Test

1.13.1 Test Description:

- Student A will drive the 2012 Chevrolet Cruze, but instead of sequential shifting, student will skip gears.
- While driving, test to cover all possible combinations, following **Table 3**. (i.e. skipping from 1st gear to 3rd gear, then 1st gear to 4th gear and so on. Test to be completed at different RPM values for each of the current gears, 3 - 5 different RPMs).
- Test to be completed upshifting and downshifting.
- Student A is to try to match the revolutions when downshifting and should try to rev up the engine, or not let the car stall when upshifting.

1.13.2 Test Goal

- Collect data of the 2012 Chevrolet Cruze's RPM behavior as its skipping gears.

1.14 Improper Gear Skipping Test

1.14.1 Test Description:

- Student A will be driving, but instead of sequential shifting, student will skip gears.

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- While driving, test to cover all possible combinations, following **Table 3**. (i.e. skipping from 1st gear to 3rd gear, then 1st gear to 4th gear and so on. Test to be completed at different RPM values for each of the current gears, 3 - 5 different RPMs).
- Test to be completed upshifting and downshifting.
- Student A is to try to NOT match the revolutions when downshifting and Student A should try NOT to rev up the engine and let the car stall (if car can't handle the skipped upshift) when upshifting.

1.14.2 Test Goal

- Collect data of the 2012 Chevrolet Cruze's RPM as its skipping gears erroneously.

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2. Automatic Transmission Data Collection

2.1 Hill Lower RPM/Velocity Test

2.1.1 Test Description:

- Install the O-Shift device into the 2010 Ford Fusion.
- Student A will drive the 2010 Ford Fusion from a 0-degree incline position and will achieve designated speed value and specified gear, as specified in **Table 1**, before going up a hill. Student A will attempt to maintain constant speed as the vehicle goes up the hill.
- Test to be repeated & completed on different hills with measured inclination, 3-5 different value slopes.
- Test will be repeated following the outline in **Table 1**.

2.1.2 Test Goal:

- The goal of the test is to verify that the lower rpm/velocity value the 2010 Ford Fusion matches that of the 2012 Chevrolet Cruze.

2.2 Uphill Start Baseline RPM Test

2.2.1 Test Description:

- Install the O-Shift device into the 2010 Ford Fusion.
- Student A will start with the 2010 Ford Fusion stopped at the base of a hill. Student A will attempt to go up the hill without touching the accelerator pedal. If there is a need to press the gas pedal, press as lightly and slowly as possible until the car achieves motion. Repeat this test 3-5 times to achieve an average of results.

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- Student A will then drive the 2010 Ford Fusion up the hill using clutch and gas pedal to simulate a real uphill start. Repeat this test 3-5 times to achieve an average of results.
- Student A will repeat these tests with erroneous clutch & gas pedal timing to simulate car rolling back, stalling conditions & jarring.
- Test to be repeated & completed on different hills with measure inclination, 3-5 different value hills.

2.2.2 Test Goal:

- The goal of the test is to collect the data needed to identify the 2010 Ford Fusion's minimum RPMs to move up in a specific hill and verify it matches the 2012 Chevrolet Cruze. This test will also gather data on car behavior (RPM, Velocity & Clutch Position) of normal uphill, rolling back and stalling conditions.

2.3 Changing Gears Uphill RPM Test

2.3.1 Test Description:

- Install the O-Shift device into the 2010 Ford Fusion.
- Student A will drive the 2010 Ford Fusion at a constant RPM value into a known degree elevation hill. Maintaining the current RPM, shift into next sequential gear.
- Record RPM data for this test.

2.3.2 Test Goal:

- Verify that the 2010 Ford Fusion's RPMs variance when changing gears uphill matches that of the 2012 Chevrolet Cruze.

2.4 Clutch Riding RPM Variance Test

2.4.1 Test Description:

- Install the O-Shift device into the 2010 Ford Fusion.
- Student A will be driving the 2010 Ford Fusion while Clutch Riding (having the clutch partially engaged when the vehicle is in motion). This test will be completed in short intervals (> 5 mins) to prevent permanent damage to the clutch. Repeat the test 10-15 times.
- Record the RPM data from the interval testing.

2.4.2 Test Goal

- Verify that the 2010 Ford Fusion's RPMs variance when Clutch Driving matches that of the 2012 Chevrolet Cruze.

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2.5 Gentle Driving Test

2.5.1 Test Description:

- Install the O-Shift device into the 2010 Ford Fusion.
- Start the 2010 Ford Fusion. At a standstill, shift into 1st gear, gently release the clutch, and start moving. Accelerate at a gentle pace. Short-shift into higher gears when accelerating. Do not exceed 40% throttle input and do not exceed 2500RPM. Drive along side streets, limited highway driving. Cruise at or below 1500RPM.
- Repeat for 1 hour of driving.

2.5.2 Test Goal:

- Verify that the 2010 Ford Fusion's shift pattern for a typical, easy-going driving style matches that of the 2012 Chevrolet Cruze.

2.6 Aggressive Driving Test

2.6.1 Test Description:

- Install the O-Shift device into the 2010 Ford Fusion.
- Start the 2010 Ford Fusion. At a standstill, shift into 1st, release the clutch and start moving. Accelerate at a brisk pace. Carry out the RPMs to approximately 4000RPM when accelerating in lower gears. Get up to traffic speed quickly. Drive along main roads, incorporate highway driving as well. (**DO NOT EXCEED THE SPEED LIMIT**).
- Repeat for 1 hour of driving.

2.6.2 Test Goal:

- Verify that the 2010 Ford Fusion's shift pattern for a typical "aggressive" driving style matches that of the 2012 Chevrolet Cruze.

2.7 Late Shifting Test

2.7.1 Test Description:I

- Install the O-Shift device into the 2010 Ford Fusion.

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- Student A will be driving the 2010 Ford Fusion conservatively (<2500RPMs) but will be shifting late. Drive for 1 hour.
- Shifting late is defined as releasing the clutch completely before touching the gas pedal.

2.7.2 Test Goal:

- Collect data on the 2010 Ford Fusion's RPMs of a poorly timed shift and ensure it matches that of the 2012 Chevrolet Cruze.

2.8 Early Shifting Test

2.8.1 Test Description:

- Install the O-Shift device into the 2010 Ford Fusion.
- Student A will be driving conservatively (<2500RPMs) but will be shifting early. Drive for 1 hour.
- Shifting early is defined as pressing on the gas pedal before the full release of the clutch.

2.8.2 Test Goal:

- Collect data on the 2010 Ford Fusion's RPMs of a poorly timed shift and ensure it matches that of the 2012 Chevrolet Cruze.

2.9 Rolling Stop-Start Test

2.9.1 Test Description:

- Install the O-Shift device into the 2010 Ford Fusion.
- Start the 2010 Ford Fusion. Begin driving along a side street.
- Approach a stop sign and apply the brake to slow down.
- Lower the current gear to 2nd at least 200ft before the stop sign.
- Fully depress the clutch and coast at ~5mph until reaching the stop line.
- Release the clutch, still in 2nd gear, and begin accelerating again.
- Repeat 10 times for accuracy.
- This test will be repeated following **Table 2**.

2.9.2 Test Goals:

- Verify that the RPM vs speed patterns for low-speed stop-start conditions on the 2010 Ford Fusion match those of the 2012 Chevrolet Cruze.

2.10 Early Release Stall Test

2.10.1 Test Description

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- Install the O-Shift device into the 2010 Ford Fusion.
- Start the 2010 Ford Fusion. At a standstill, shift into 1st and quickly release the clutch without providing any throttle input.
- Re-start the car and repeat for 2nd and reverse.

2.10.2 Test Goal

- Verify the speed one must release the clutch to induce stalling conditions in the 2010 Ford Fusion matches those of the 2012 Chevrolet Cruze.

2.11 Complete Stop Stall Test

2.11.1 Test Description

- Install the O-Shift device into the 2010 Ford Fusion.
- Start the 2010 Ford Fusion and start moving. While the car is in motion, press the brake to slow the car down. Do not press the clutch or shift out of the current gear, and allow the car to stall.
- Repeat the stalling condition for reverse and each gear.

2.11.2 Test Goal

- Verify the RPM behavior during stall conditions (min. RPM achieved before stall condition) for the 2010 Ford Fusion matches that of the 2012 Chevrolet Cruze.

2.12 Calibration RPM-to-Velocity Test

2.12.1 Test Description

- Install the O-Shift device into the 2010 Ford Fusion.
- Connect the data logging device to the 2010 Ford Fusion's OBD-II port
- Student A will start on level ground and an open road with the car stopped.
- Student A will engage the clutch and shift into 1st gear, slowly accelerating the car to redline in 1st gear.
- After reaching redline, shift up into 2nd gear and let the RPMs drop until near-idle RPM is reached (prevent stalling).
- Repeat this procedure for each of the remaining gears. For higher gears where speeds at higher RPM are unreasonable (and illegal), only go up to ~3500 RPM or the legal speed limit, whichever occurs first.
- Repeat again from a standstill for reverse gear.
- Repeat entire test at least 3-5 times for accuracy.

2.12.2 Test Goals

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- Verify that the direct mapping/relationship between the RPM of each gear and the associated vehicle speed in the 2010 Ford Fusion matches that of the 2012 Chevrolet Cruze

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2.13 Proper Gear Skipping Test

2.13.1 Test Description:

- Install the O-Shift device into the 2010 Ford Fusion.
- Student A will drive the 2010 Ford Fusion, but instead of sequential shifting, student will skip gears.
- While driving, test to cover all possible combinations, following **Table 3**. (i.e. skipping from 1st gear to 3rd gear, then 1st gear to 4th gear and so on. Test to be completed at different RPM values for each of the current gears, 3 - 5 different RPMs).
- Test to be completed upshifting and downshifting.
- Student A is to try to match the revolutions when downshifting and should try to rev up the engine, or not let the car stall when upshifting.

2.13.2 Test Goal

- Verify the data of the 2010 Ford Fusion's RPM behavior as its skipping gears matches that of the 2012 Chevrolet Cruze.

2.14 Improper Gear Skipping Test

2.14.1 Test Description:

- Install the O-Shift device into the 2010 Ford Fusion.
- Student A will be driving, but instead of sequential shifting, student will skip gears.
- While driving, test to cover all possible combinations, following **Table 3**. (i.e. skipping from 1st gear to 3rd gear, then 1st gear to 4th gear and so on. Test to be completed at different RPM values for each of the current gears, 3 - 5 different RPMs).
- Test to be completed upshifting and downshifting.
- Student A is to try to NOT match the revolutions when downshifting and Student A should try NOT to rev up the engine and let the car stall (if car can't handle the skipped upshift) when upshifting.

2.14.2 Test Goal

- Verify the data of the 2010 Ford Fusion's RPM as its skipping gears erroneously matches that of the 2012 Chevrolet Cruze.

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Mechanical Tests:

3. Mechanical Clutch Pedal Tests

3.1 Force Sensor Calibration

3.1.1 Test Description:

- Connect the Force Sensor to the compatible data logging device and power it on.
- Add a 10lb weight to the force sensor and measure output.
- Add another 10lb weight to the force sensor and measure output.
- Repeat this process 5x.

3.1.2 Test Goal:

- The goal of the test is to calibrate the force sensor.

3.2 Static Clutch Pedal Force Determination Test

3.2.1 Test Description:

- Connect the Force Sensor to the compatible data logging device and power it on.
- Affix the Force Sensor to the 2012 Chevrolet Cruze's clutch pedal with duct tape so the sensor's button is facing downward. Ensure the sensor is firmly in place.
- Student A will sit in the driver's seat of the 2012 Chevrolet Cruze (which will not have the engine running) and begin to depress the pedal to the floor in a comfortable and normal fashion.
- Student A will keep the pedal in the fully depressed position for roughly 5 seconds.
- Repeat this process 5 times.

3.2.2 Test Goal:

- The goal of the test is to understand the typical amount of force a person exerts on a clutch pedal in a static position.

3.3 Dynamic Clutch Pedal Force Determination Test

3.3.1 Test Description:

- Connect the Force Sensor to the compatible data logging device and power it on.

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- Affix the Force Sensor to the 2012 Chevrolet Cruze's clutch pedal with duct tape so the sensor's button is facing downward. Ensure the sensor is firmly in place.
- Student A will sit in the driver's seat of the 2012 Chevrolet Cruze and start the engine of the vehicle.
- Student A will drive the 2012 Chevrolet Cruze, depressing the car's pedals as normal, around a specified circuit (roughly 10 minutes of normal driving).
- Return the vehicle to rest and turn off the car.

3.3.2 Test Goal:

- The goal of the test is to understand the typical amount of force a person exerts on a clutch pedal while driving the vehicle.

3.4 Static O-Shift Pedal Validation Force Test

3.4.1 Test Description:

- Connect the Force Sensor to the compatible data logging device and power it on.
- Affix the Force Sensor to the 2010 Ford Fusion's clutch pedal with duct tape so the sensor's button is facing downward. Ensure the sensor is firmly in place.
- Student A will sit in the driver's seat of the 2010 Ford Fusion (which will not have the engine running) and begin to depress the pedal to the floor in a comfortable and normal fashion.
- Student A will keep the pedal in the fully depressed position for roughly 5 seconds.
- Repeat this process 5 times.

3.4.2 Test Goal:

- The goal of the test is to verify that the amount of force a user exerts on the O-Shift clutch pedal device is similar to what is exerted on a typical clutch pedal in a static position.

3.5 Dynamic O-Shift Pedal Validation Force Test

3.5.1 Test Description:

- Connect the Force Sensor to the compatible data logging device and power it on.
- Affix the Force Sensor to the 2010 Ford Fusion's clutch pedal with duct tape so the sensor's button is facing downward. Ensure the sensor is firmly in place.

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- Student A will sit in the driver's seat of the 2010 Ford Fusion and start the engine of the vehicle.
- Student A will drive the 2010 Ford Fusion, depressing the car's pedals as normal, around a specified circuit (roughly 10 minutes of normal driving).
- Return the vehicle to rest and turn off the car.

3.5.2 Test Goal:

- The goal of the test is to verify that the amount of force a user exerts on the O-Shift clutch pedal device is similar to what is exerted on a typical clutch pedal in a dynamic position.

3.6 Ultrasonic Sensor Feasibility

3.6.1 Test Description:

- Connect the Ultrasonic Sensor to the compatible data logging device and power it on.
- Using Student A's hands, hold the Ultrasonic Sensor flush to the 2010 Ford Fusion's dead pedal zone, positioned so that the device's sensor is pointed towards the car's brake pedal. Keep the sensor as steady as possible.
- Student B will sit in the driver's seat of the 2010 Ford Fusion and start the engine of the vehicle.
- Student B will depress the brake pedal to the floor in a comfortable and normal fashion.
- Student B will keep the pedal in the fully depressed position for roughly 5 seconds.
- Repeat this process 5 times.
- Student A will now place the Ultrasonic Sensor directly adjacent to the 2010 Ford Fusion's dead pedal zone on the floor towards the center of the Fusion (not towards the vehicle's seat). Student A will hold the Ultrasonic Sensor as close to the dead pedal zone as possible, so as to not obstruct the motion of the break pedal. The device's sensor will be pointed again towards the car's brake pedal.
- Student B will again depress the brake pedal to the floor in a comfortable and normal fashion.
- Student B will keep the pedal in the fully depressed position for roughly 5 seconds.
- Repeat this process 5 times.
- Turn off the vehicle.

3.6.2 Test Goal:

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- Test the feasibility of using an ultrasonic sensor to measure the height of the clutch pedal as well as the height of the brake pedal.

3.7 Max Foot Force Test

3.7.1 Test Description:

- Student A will go to the leg press machine at a gym.
- Student A will add plates to the machine and complete a one-rep max leg press with both legs.
- Student A will adjust the weight on the machine and complete a one-rep max leg press with each individual leg.
- Student A will calculate the force exerted, based on the weight on the machine, the weight of the sled, and the angle of the sled.

3.7.2 Test Goal:

- The goal of the test is to determine the maximum force a single leg can exert on a pedal.

3.8 Static O-Shift Clutch Pedal Max Stress Test

3.8.1 Test Description:

- Install the clutch pedal unit into the 2010 Ford Fusion.
- Student A will sit in the driver's seat of the 2010 Ford Fusion.
- Student A will depress the clutch pedal until 213lbf is achieved.

3.8.2 Test Goal:

- The goal of the test is to verify that the amount of force a user exerts on the O-Shift clutch pedal device does not risk the structural stability of the unit.

3.9 Static Clutch Pedal Max Torsion Test

3.9.1 Test Description:

- Install the clutch pedal unit into the 2010 Ford Fusion.
- Student A will sit in the driver's seat of the 2010 Ford Fusion.
- Student A will depress the clutch pedal with until 213lbf is achieved.

3.9.2 Test Goal:

- The goal of the test is to verify that the amount of force a user exerts on the O-Shift clutch pedal device does not cause the base of the pedal to lift off the floor of the car.

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4. Mechanical Shifter Housing Tests

4.1 Max Push Force Test

4.1.1 Test Description:

- Student A will go to the chest machine at a gym.
- Student A will add plates to the machine and complete a one-rep max chest press with both arms.
- Student A will adjust the weight on the machine and complete a one-rep max chest press with each individual arm.

4.1.2 Test Goal:

- The goal of the test is to determine the maximum force a single arm can exert in a pushing fashion, similar to the shifting motion.

4.2 Max Pull Force Test

4.2.1 Test Description:

- Student A will go to the seated row machine at a gym.
- Student A will add weight to the machine and complete a one-rep max row with both arms.
- Student A will adjust the weight on the machine and complete a one-rep max row with each individual arm.

4.2.2 Test Goal:

- The goal of the test is to determine the maximum force a single arm can exert in a pulling fashion, similar to the shifting motion.

4.3 Max Push O-Shift Stress Test

4.3.1 Test Description:

- Connect the Force Sensor to the compatible data logging device and power it on.
- Install the shifter unit into the 2010 Ford Fusion.
- Student A will hold the Force Sensor in the palm of his/her hand and sit in the driver's seat of the 2010 Ford Fusion.
- Student A will push the shifter until 110lbf is achieved.

4.3.2 Test Goal:

- The goal of the test is to verify that the amount of force a user exerts in a pushing motion on the O-Shift shifter unit does not risk the structural stability of the unit.

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4.4 Max Pull O-Shift Stress Test

4.4.1 Test Description:

- Connect the Force Sensor to the compatible data logging device and power it on.
- Install the shifter unit into the 2010 Ford Fusion.
- Student A will hold the Force Sensor in the palm of his/her hand and sit in the driver's seat of the 2010 Ford Fusion.
- Student A will pull the shifter until 125lbf is achieved.

4.4.2 Test Goal:

- The goal of the test is to verify that the amount of force a user exerts in a pulling motion on the O-Shift shifter unit does not risk the structural stability of the unit.

Electrical & Other Tests :

5. Response Time

5.1 Delay Measurement Between Clutch and Display

5.1.1 Test Description:

- Connect logic analyzer to clutch input port and test I/O on display board.
- Student A will depress O-Shift clutch pedal to the floor of the 2010 Ford Fusion.
- Use logic analyzer to measure time delay between trigger from clutch input and toggle on test I/O.

5.1.2 Test Goal:

- The goal of the test is to verify that the device responds to user commands and provides feedback in under 200ms.

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6. ISO and SAE Standards

6.1 Compliance Test

6.1.1 Test Description:

- Install O-Shift units into 2010 Ford Fusion.

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- Verify that the O-Shift OBD-II connector mates properly with the 2010 Ford Fusion's OBD-II port.
- Student A will turn on the car and verify that speed and RPM data are being received and shown on the driver display and match numbers shown on speedometer and tachometer.

6.1.2 Test Goal:

- Ensure system adheres to ISO-11898 CAN2.0B, SAE J1939, SAE J1979, SAE J1962, SAE J2284-3 (These are standards for automotive CAN networks and OBD-II specifications).

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7. Driving Log Size

7.1 Verify Log Size

7.1.1 Test Description:

- Student A will run the O-Shift system for 5 minutes and record the size of the corresponding driving log.
- Student A will then convert the driving log file to MB per minute.
- Repeat this test 4 more times and average the log rates found (MB per minute).
- Use the achieved rate to estimate the time to reach a 8GB driving log.
- Verify that this time estimate is greater than 5 hours.

7.1.2 Test Goal:

- The goal is to show that the maximum driving log size of 8GB will not be exceeded during a "normal" driving session (<2 hours).

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8. Subsystems Communications

8.1 Verify Communications

8.1.1 Test Description:

- The shifter and the display is to receive the clutch data when is engaged. This shall signal the lock-out mechanism in the shifter to move.
- The display is to receive information from the shifter for each proper gear.

8.1.2 Test Goal:

- Ensure all the subsystems are communicating properly with each other in a response time less of 0.25 seconds.

8.2 Clutch Sensor Binary Response Test

8.2.1 Test Description:

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- Clutch pedal will be installed with all sensors and left undepressed.
- Student A will verify that the sensor reads that the clutch is not depressed.
- Student A then fully depresses the clutch and verifies that the sensor reads as depressed.
- Student A will then test the engagement point of the clutch by incrementally depressing the clutch from an uncompressed position
- Student A will stop changing clutch position at the point in which the sensor state changes while Student B measures the distance from the pedal to the car floor (using a ruler perpendicular to the floor)
- The engagement point will then be measured two more times and the results will be averaged
- Student A will then test the disengagement point of the clutch by incrementally raising the clutch from a fully depressed position.
- Student A will stop changing clutch position at the point in which the sensor state changes while Student B measures the distance from the pedal to the car floor (using a ruler perpendicular to the floor)
- The disengagement point will then be measured two more times and the results will be averaged.
- Both the engagement and disengagement points should be within +/- 1cm of half the full clutch range of motion (measured from pedal to the car floor)

8.2.2 Test Goal:

- Ensure the state of the clutch changes at a comfortable point

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8.3 Shifter Sensor Binary Response Test

8.3.1 Test Description:

- Shifter unit will be assembled with all sensors and the shifter will be out of gear.
- Student A will verify that each of the 7 gear switches reads as out of that gear.
- Student A then move the shifter knob into first gear.
- Student A will verify that the switch for first gear correctly reads that the shifter is in gear 1, and all other switches read that the shifter is not in their locations.

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- Student A will repeat this test for gears 2-6 and reverse.

8.3.2 Test Goal:

- Ensure all limit switches in the shifter are correctly determining gear.

8.4 Shifter Solenoid Test

8.4.1 Test Description:

- Shifter unit will be assembled with solenoids and sliding plates installed.
- Student A will engage the solenoids and verify that the plates move.
- Student A will shift into first gear, and disengage the solenoids.
- Student A will verify that the plates move again, and that the plate is against the shifter shaft.
- Student A will verify that the plate holds the shifter in first gear.
- Student A will engage the solenoids and verify that the plates move again, and that they release the shifter shaft.
- This test shall be repeated for gears 2-6 and reverse.

8.4.2 Test Goal:

- This test will ensure solenoids and sliding plates operate as intended.

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Appendix:

Test 1.1 Hill Lower RPM/Velocity Test - Table 1 Data

Table Raw Data Link

			The values will be different according to the available hills to which the test can be performed safely			
Gear	Inclination/ Speed	Recorded Avg. RPM				
1	5					
	10					
2	10					
	15					
	20					
	25					
3	15					
	20					
	25					
	30					
	35					
4	25					
	30					
	35					
	40					
	45					
5	35					
	40					
	45					
	50					

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	55					
6	45					
	50					
	55					
	60					
	65					

Legend	
Criteria:	Giving a +- 2 m/h
M	Maintained Speed
S	Slowed Down
X	Stalled/Didn't go up

Test 1.9 Rolling Stop-Start Test - Table 2 Data

Table Raw Data Link

Gear/ Speed	1	2	3	4	5	6
5						
10						
15						
20						
25						
30						
35						
40						
45						

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50						
55						
60						
65						
70						
75						
80						
85						

Legend	
Criteria:	Giving a +- 2 m/h
M	Recovered Speed
S	Slowed Down/ Struggle
X	Stalled

Test 1.13&14 Proper/Improper Gear Skipping Test - Table 3 Data

Table Raw Data Link

	Upshifting						
RPMs	1	2	3	4	5	6	**Gear**
1500					N	N	6
				N	N	N	5
			N	N	N	N	4
		N	N	N	N	N	3

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	N	N	N	N	N	N	2
	N	N	N	N	N	N	1
2000					N	N	6
				N	N	N	5
			N	N	N	N	4
		N	N	N	N	N	3
	N	N	N	N	N	N	2
	N	N	N	N	N	N	1
2500					N	N	6
				N	N	N	5
			N	N	N	N	4
		N	N	N	N	N	3
	N	N	N	N	N	N	2
	N	N	N	N	N	N	1
3000					N	N	6
				N	N	N	5
			N	N	N	N	4
		N	N	N	N	N	3
	N	N	N	N	N	N	2
	N	N	N	N	N	N	1
3500					N	N	6
				N	N	N	5
			N	N	N	N	4
		N	N	N	N	N	3
	N	N	N	N	N	N	2
	N	N	N	N	N	N	1

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	Downshifting						
RPMs	1	2	3	4	5	6	**Gear**
1500	N	N	N	N	N	N	6
	N	N	N	N	N	N	5
	N	N	N	N	N		4
	N	N	N	N			3
	N	N	N				2
	N	N					1
2000	N	N	N	N	N	N	6
	N	N	N	N	N	N	5
	N	N	N	N	N		4
	N	N	N	N			3
	N	N	N				2
	N	N					1
2500	N	N	N	N	N	N	6
	N	N	N	N	N	N	5
	N	N	N	N	N		4
	N	N	N	N			3
	N	N	N				2
	N	N					1
3000	N	N	N	N	N	N	6
	N	N	N	N	N	N	5
	N	N	N	N	N		4
	N	N	N	N			3
	N	N	N				2
	N	N					1
3500	N	N	N	N	N	N	6
	N	N	N	N	N	N	5
	N	N	N	N	N		4

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	N	N	N	N			3
	N	N	N				2
	N	N					1

Legend	
Criteria:	
M	Maintain Speed
S	Slowed Down/ Struggle
X	Stalled
N	Not Valid

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