



# **ASE 4 - Suspension and Steering**

## **Module 5 Vibration Correction**

# Acknowledgements

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# Introduction

The purpose of this training course is to provide technicians with a better understanding of the types of vehicle vibrations that result in customer concerns, to guide technicians toward using a systematic approach and the proper diagnostic tools for identifying the causes of vibrations, and to encourage technicians to following the recommended service procedures for reducing or eliminating vehicle vibrations.

## Objectives

### NATEF Area A3 and A4 III. Manual Drive Train And Axles

- General Drive Train Diagnosis
  - Diagnose transaxle final drive assembly noise and vibration concerns; determine necessary action.
  - Drive Shaft and Half Shaft, Universal and Constant-Velocity (CV) Joint Diagnosis and Repair
  - Diagnose constant-velocity (CV) joint noise and vibration concerns; determine necessary action.
  - Diagnose universal joint noise and vibration concerns; perform necessary action.
  - Check shaft balance; measure shaft run-out; measure and adjust driveline angles.
  - Drive Axle Diagnosis and Repair
  - Diagnose noise and vibration concerns; determine necessary action.
  - Inspect and replace companion flange and pinion seal; measure companion flange run-out.
- Drive Axle Shaft
  - Diagnose drive axle shafts, bearings, and seals for noise, vibration, and fluid leakage concerns; determine necessary action.
  - Inspect and replace drive axle shaft wheel studs.
  - Measure drive axle flange run-out and shaft endplay; determine necessary action.
- Four-wheel Drive/All-wheel Drive Component Diagnosis and Repair
  - Diagnose noise, vibration, and unusual steering concerns; determine necessary action.



## STC Tasks:

### A-3/4 Competencies for Vibration Correction 13042.10

#### B. Noise

- Identify and describe characteristics of - Noise.

#### C. Vibration

- Identify and describe the characteristics and types of vibrations
- Describe first order vibrations
- Describe second order vibrations
- Describe third order vibrations
- Describe force vibrations
- Describe wheel and tire assembly vibrations
- Describe force variations
- Describe the Torque sensitive driveline vibrations
- Describe the front wheel drive driveline vibrations
- Describe free vibrations
- Describe engine related vibrations

## Student Workbook

### ASE 4 - Suspension and Steering

### Module 5 - Vibration Correction



# Lesson 1: Diagnostic Principles

## Introduction

During the last 10 to 15 years, options such as air conditioning, power steering, and all-wheel drive have become more and more popular. These types of options increase engine load and also can generate unwanted noise and vibration.

Customer perception of quality can be directly linked to the presence or absence of unwanted noise and vibration.

## Objective

This module will enable you to describe noise concerns.

- Identifying the concern
- Classifying the vibration
- Matching frequency to component
- Tire and wheel assembly vibrations

## Identifying the Concern

The first step in diagnosing a vibration is identifying exactly what is the customer's concern.

However, when identifying a concern, remember:

- All vehicles produce vibrations; and
- Some vibrations are normal and cannot be repaired

Also, remember the vibration may be easily duplicated at a given speed.

## Common Causes

- The components in each group are related to each other, because they are either bolted or splined together
- Therefore, they rotate at the exact same speed. This is important because vibrations are directly related to the rotational speed of the component

Note:

Before you attempt to correct a vibration concern, you should determine if the vibration is normal for the vehicle being serviced.

If an attempt is made to repair what may be a normal condition, the customer will be convinced that a true concern exists, and satisfying that customer becomes much more difficult.

## Acceptable Vibrations

If the vibration occurs only with a fully loaded trailer attached, or if it has occurred only since the time the vehicle was in an accident, the technician must be made aware of these facts to quickly identify the cause.

The following comparisons may be made if a vibration is suspected as being normal for a specific model:

### Determine Acceptable Vibrations

- Compare the vehicle with another vehicle that is equipped in the same way:
  - Body style
  - Engine option
  - Tire size
  - Axle ratio
  - Operating conditions
- If necessary, make the comparison with the customer present and explain the situation.

### Road Testing

Road testing is performed to duplicate the concern and to find operating conditions that change or eliminate the vibration.

- It can help determine whether vibration is related to engine speed or road speed.
- Should be performed on smooth, level surfaces
- Verify that interpretation of customer concern is correct.

## Different Types Of Road Tests

- Tire inspection
- Slow acceleration test
- Neutral coast-down test
- Downshift test

These tests should be performed for all vibration concerns, unless the disturbance occurs with the vehicle at a standstill.

## Tire Inspection

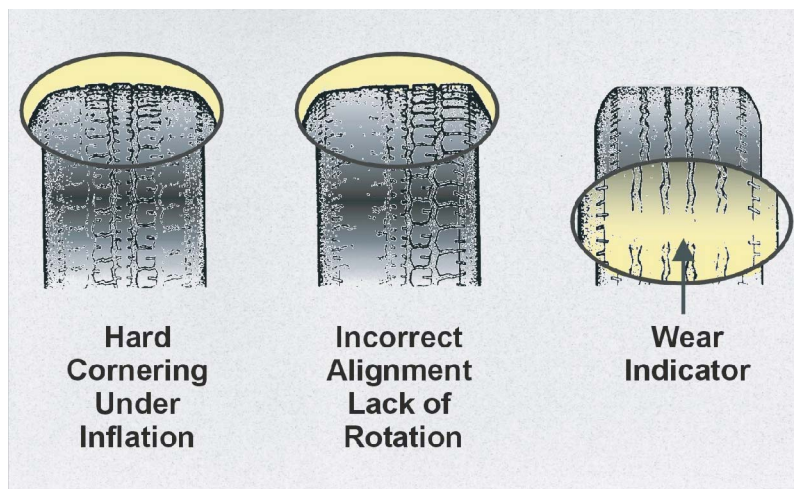
Spending a few minutes examining the condition of the tire and wheel assemblies may lead to the source of the concern.

Inspect the following items when performing the tire and wheel inspection.

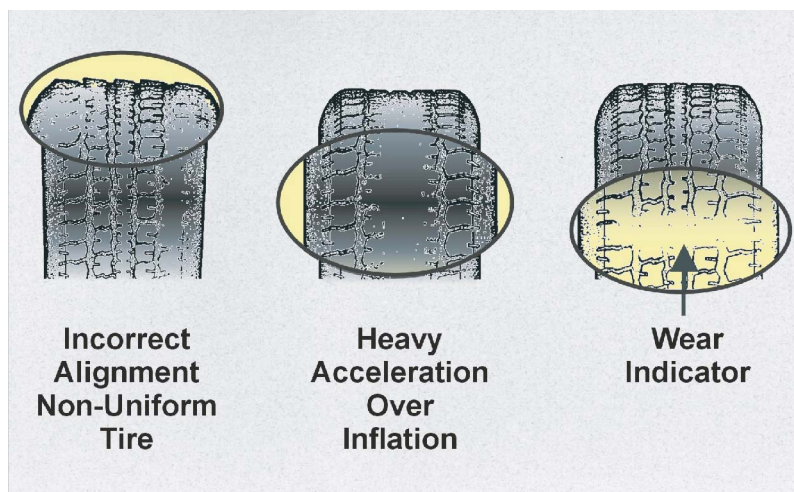
- Unusual wear
  - Includes cupping, flat spots, and heel-and-toe wear
  - Can cause:
    - Tire growl
    - Howl
    - Slapping noises
    - Vibrations throughout vehicle
- Proper inflation
  - Ensure each tire is inflated to appropriate specification for vehicle
  - Correct improper inflation prior to continuing diagnosis
- Bulges in sidewall
  - Do not confuse with normal ply splices seen as indentions in sidewall
  - May indicate bent rim flanges
- Dented hubcaps or trim rings also may indicate bent wheels.
- Refer to the service information for tire replacement.

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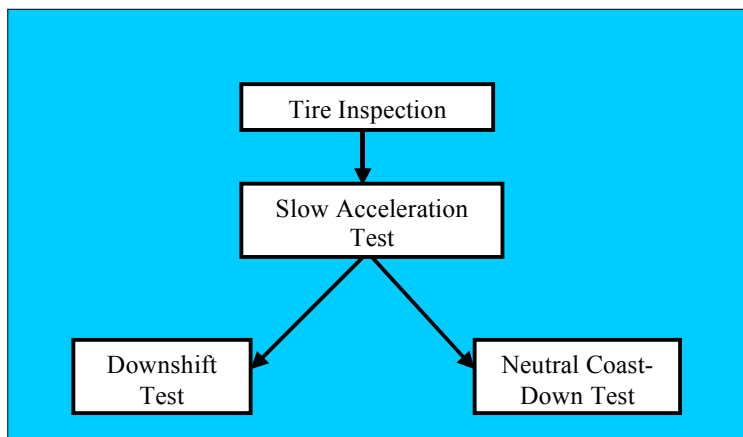
*Figure 5-1, Tire Wear Patterns*



*Figure 5-2, Tire Wear Patterns*

## Speed-Related Vibrations

The following tests are performed during a road test to aid in identifying and categorizing vibration concerns.



**Vibration concerns can be categorized into two groups:**

- Vehicle speed
- Engine RPM

**The Slow Acceleration Test** is used to identify engine or vehicle-speed-related conditions.

**The Neutral Coast-Down Test and Downshift Test** should be performed to help determine which category the vibration belongs.

**The Neutral Coast-Down Test** is used to identify concerns sensitive to vehicle speed. This test:

- Eliminates the engine and torque converter as a vibration cause
- Concentrates the repair on the tires and wheels, or on the propshaft and rear (driving) axle based on symptoms

**The Downshift Test is used to identify Engine speed-related concerns.**

- If the vibration returns at the same rpm, the engine and torque converter are the most probable causes.
- In some cases, a vibration may be sensitive to torque or engine load.
- These vibrations can be the most difficult to diagnose, and may require additional testing.

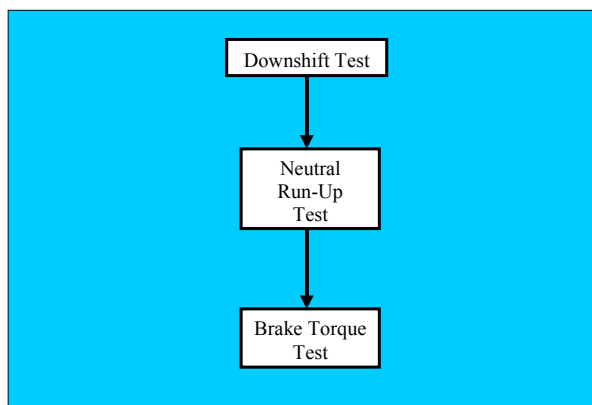
### Engine Speed-Related Vibrations

#### Notice:

The Neutral Run-Up Test and Brake Torque Test are used for engine speed-related vibrations.

## Neutral Run-Up Test

- Identifies engine speed-related vibrations
- Use this test whenever customer expresses a concern about vibration at idle, or as a follow-up to Downshift Test



## Brake Torque Test

- Identifies engine-speed-related vibrations not revealed by the Neutral Run-Up Test
- Works also for vibrations that are sensitive to engine load or torque.

### Notice:

Do not accelerate against the brakes for longer than 15 seconds.

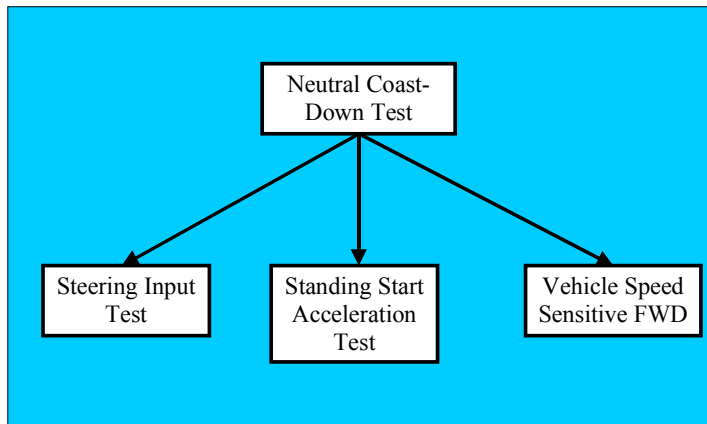
Care should be taken not to overheat the engine or transmission.

Depending on the vehicle design, the engine will only rev to a certain point under these conditions.

Also, care should be taken during diagnosis because some disturbances may be created during brake torque that normally do NOT exist.

## Vehicle Speed-Related Vibrations

One or more of the following tests may be necessary for some unique vibration concerns, such as those that are torque/load-sensitive in addition to mph or Rpm sensitive.



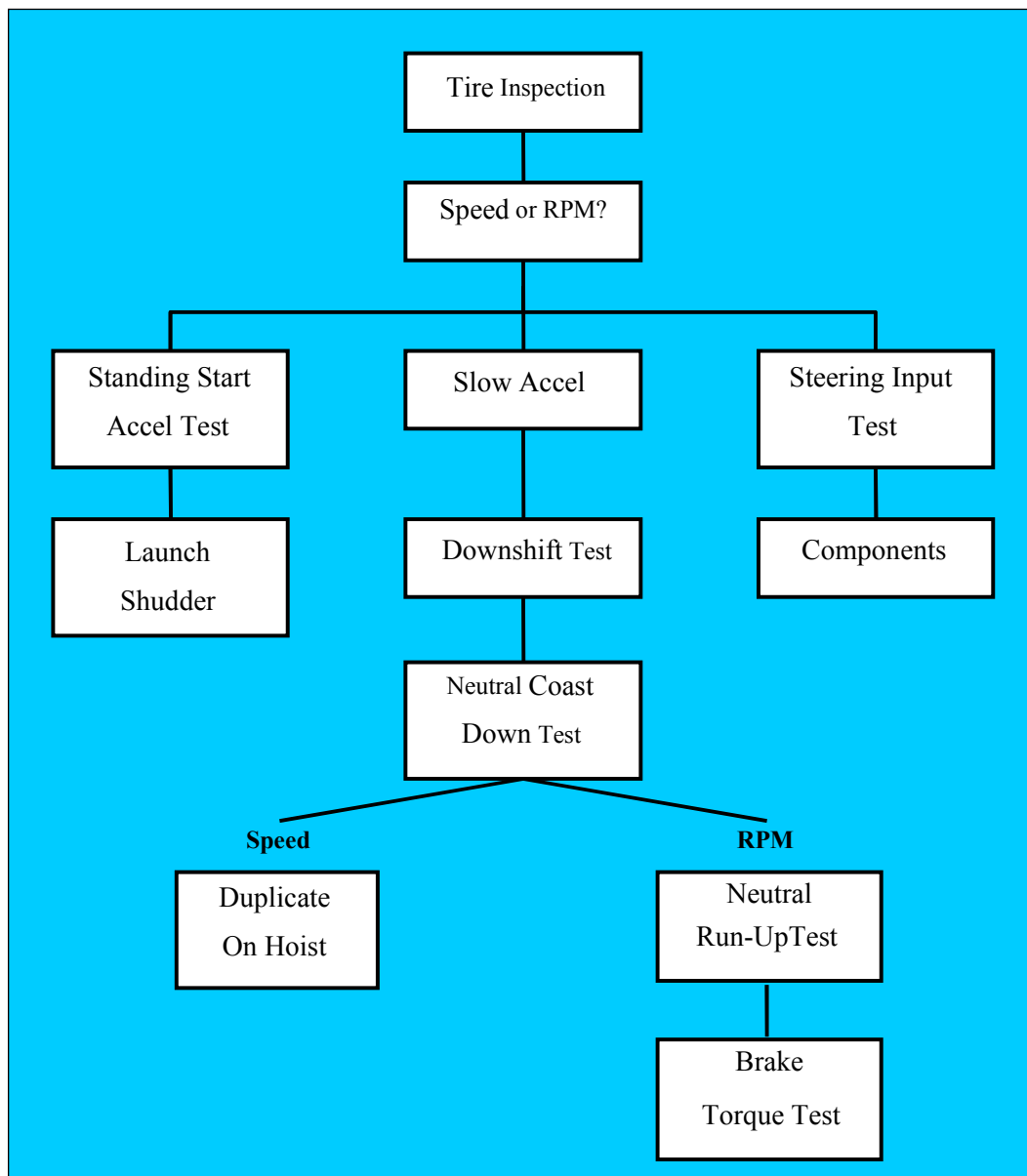
### Purpose Of Each Test

- Steering Input Test is used to determine how much wheel bearings and other suspension components contribute to a vibration.
- Standing Start Acceleration Test is used to duplicate launch shudder, or when a Powertrain mount or exhaust ground out is suspected.



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### ASE 4 - Suspension and Steering

### Module 5 - Vibration Correction

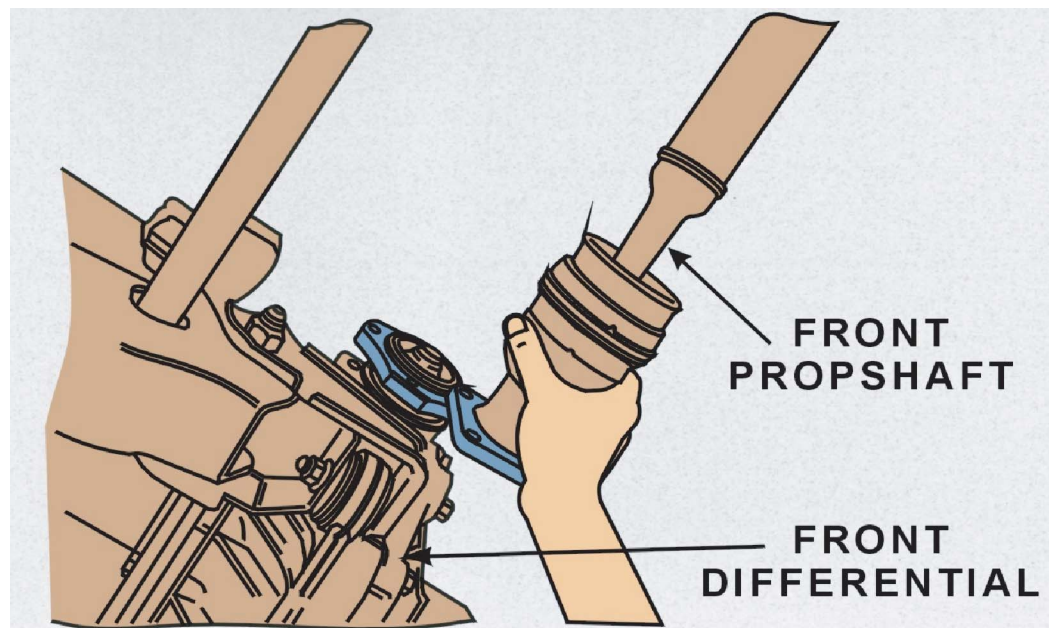


Figure 5-3,

#### Describe 4wd/Awd Vehicle Test

- Mark propshaft and flanges
- Remove either the front or rear propshaft and drive the vehicle through the vibration speed range

If removing either propshaft does not eliminate the vibration, chances are it's caused by the tire/wheel assembly or related components (the hub, brake rotors, drums, etc.)

Remember that accurate vibration frequency readings are important.

Reinstall with marks lined up to prevent induced vibrations

- If vibration goes away with propshaft removed, concern is probably related to that component
- If vibration does not go away, reinstall propshaft and repeat road test with other propshaft removed

#### Notice:

If you remove an all-wheel-drive propshaft for diagnosis, it is recommended that you drive no more than the needed (7 miles maximum). Additional mileage may damage the transfer case.

## Vibrations That Can Be Felt

- Shake
  - Roughness
  - Buzz
  - Tingling
- 
- Shake is a low frequency vibration, 5 to 20 Hz
    - It may be seen in steering wheel, seat, or console
    - It's similar to the feeling you get from an out-of round or imbalanced tire
    - Customers may refer to shake as a shimmy, wobble, waddle, shudder, or hop
    - It usually refers to tires, wheel brake drums or rotors if it is vehicle-speed sensitive
    - Or it may refer to the engine if it is engine RPM related
  - Roughness is a vibration with a slightly higher frequency than shake, 20 to 50 Hz
    - It is similar to holding a jigsaw
    - It is usually related to driveline components
  - Buzz is slightly higher in frequency than roughness (50 to 100 Hz)
    - It is similar to the feel of an electric razor
    - It may be felt in the hands through the steering wheel, in the feet through the floor, in the seat of the pants
    - It is often related to the exhaust system, air conditioning compressor, or other engine components
  - Tingling is the highest frequency vibration that can still be felt
    - It may sometimes produce a "pins and needles" sensation
    - Customers may say the vibration puts their hands or feet to sleep

## Vibrations That Make Noise

- Boom
  - Moan or drone
  - Howl
  - Whine
- 
- A boom is a low-frequency interior noise, 20 to 60 Hz
    - Sometimes customers may complain of pressure in the ears
    - It may be described as droning, growling, moaning, roaring, rumbling, or humming
    - It may be accompanied by a perceptible vibration (roughness); for example, a bowling ball rolling down an alley, deep thunder, or a bass drum
    - It's usually related to driveline components
  - A moan or drone is a sustained tone at low frequency (60 to 120 Hz), somewhat higher than a boom
    - Examples of similar noises include: bumblebee or blowing air across the top of a pop bottle
    - It may be described as humming, buzzing, resonance
    - It may be accompanied by a perceptible buzzing vibration
    - It is related to powertrain mounts or the exhaust system
  - A howl is a noise at mid-range frequency of 120 to 300 Hz and sounds like the wind howling
  - Whine
    - This is a prolonged high-pitched sound usually related to meshing gears or gear noise
    - It has a frequency range of 300 to 500 Hz
    - It may be described as mosquitoes, turbine engines, or vacuum cleaners

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## Matching Frequency to Component

Automotive vibrations are most often related to the rotating speed of a component. Their frequency can be calculated by determining engine speed or rotational speed of the tires and propshaft.

- Once the speed of a component (first-order tire, first-order prop) has been matched with the frequency of the vibration, refer to the service information for repair procedures
- Component speed for vehicle-speed-related concerns can be calculated using the Tire/Wheel Rotation Worksheet
- Component speed may be determined using the Electronic Vibration Analyzer (EVA)

## First, Second and Third Order Vibrations

- First order vibrations occur once per each revolution
- Second order vibrations occur twice per each revolution
- Third order vibrations occur three times per each revolution

## Tire/Wheel Rotation Worksheet

The rotational speed of the tires must be determined for vehicle-speed-related vibrations.

- Speed may be determined using the Tire/Wheel and Propshaft Rotation Worksheet found in the service manual

# TIRE/WHEEL AND PROPSHAFT ROTATION FRONT ENGINE – REAR DRIVE

## Vehicle Information

Complaint Speed: \_\_\_\_\_ mph    Year: \_\_\_\_\_ Model: \_\_\_\_\_  
 Symptom: \_\_\_\_\_    VIN: \_\_\_\_\_  
 Frequency: \_\_\_\_\_    Engine: \_\_\_\_\_ Trans: \_\_\_\_\_  
 Engine Speed: \_\_\_\_\_ rpm    Tire Size: \_\_\_\_\_ Axle Ratio: \_\_\_\_\_ : \_\_\_\_\_  
 Gear: \_\_\_\_\_    TPC Spec: \_\_\_\_\_

## Tire/Wheel Speed

Vibration Occurs at:  mph ÷ 5 (mph) =  increments of 5 mph

5 mph increments  ×  tire RPS\* at 5 mph (from chart) =  Tire/Wheel Speed, RPS (Hz) 1st order

1st order  × 2 =  2nd order

1st order  × 3 =  3rd order

## Propshaft Speed

1st order tire  ×  (axle ratio) =  Propshaft Speed, RPS (Hz) 1st order

1st order propshaft  × 2 =  2nd order

\*RPS = revolutions per second; equates to cycles per second (Hz).

## Lesson 2: Introduction to the Electronic Vibration Analyzer (EVA)

### Objective

Describe the EVA and EVA2 programs.



Figure 5-4, Electronic Vibration Analyzer (EVA)

- Hand-held device similar to a scan tool
- Powered by a standard 12-volt cigarette lighter
- Specifically designed to be very accurate and easy to use to help service technicians diagnose vibrations
- Basics apply to both original EVA, which all GM dealerships initially received, and EVA2, which is the essential tool that remaining dealerships received

### Notice:

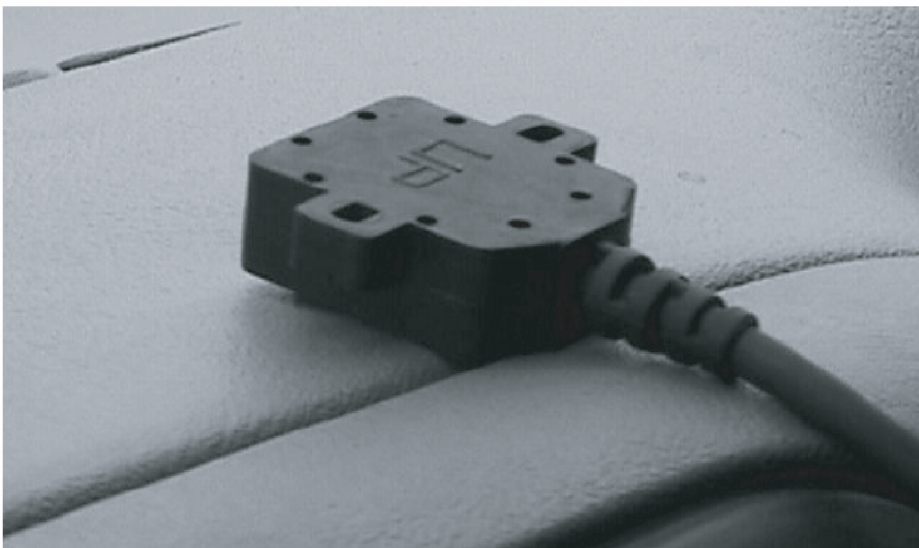
Remember, using the EVA during a road test requires two people.

### Basic hookup of the EVA

- Check that software cartridge is correctly inserted in bottom of tool
- Cartridge should be left in place at all times, even when not using the unit
- If you have one of the original EVA tools, this cartridge should be labeled "Smart EVA." The EVA2 cartridge will be labeled "EVA2".
- Next, plug the sensor cord into either the A or B input. The A input is recommended for normal use.
- To connect the sensor cord, line up the connector with the release button on the bottom. Push the connector into the input, until it clicks and locks in place

- Finally, turn the EVA On by simply plugging the power cord into a 12-volt cigarette lighter. There's no On-Off switch for the EVA
- While the sensor should remain plugged into the tool at all times; to remove the sensor cord, press the release button and gently pull the connector straight out. Never twist the connector as it may be damaged

### EVA Sensor Orientation



*Figure 5-6,*

The EVA uses an accelerometer to sense vibrations. The sensor is located at the end of a 20-foot cord and can be placed on any part of the vehicle where a vibration is felt.

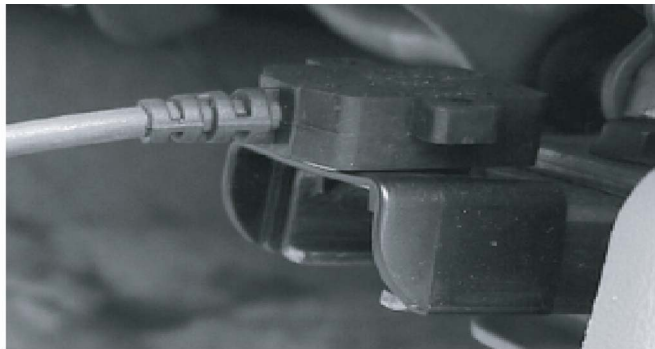
- Use putty or Velcro to hold sensor in place on nonferrous surfaces, such as instrument panel or steering column
- A magnet is supplied to mount the sensor on ferrous surfaces, such as drive train components
- The sensor is directionally sensitive and should be placed as flat as possible with the side marked "UP" facing away from the mounting surface
- For consistent results, when retesting or making a comparison, the "UP" side of the sensor must be placed in the same position every time



The following are good examples of where to place the sensor:



*Figure 5-7, Sensor Placement Steering Column*



*Figure 5-8, Sensor Placement Seat Rail*



*Figure 5-9, Sensor Placement Instrument Panel*



*Figure 5-10, Sensor Placement Front Fender*

## EVA Key Pad Functions

### Yes and No Keys

- Used to select a filter range when in the strobe balancing mode

### Up and Down Arrow keys, one pointing up and one down

- Used to move through the individual frames of a snapshot during freeze in playback mode
- Pressing Up arrow moves forward one frame, while pressing Down arrow moves back one frame

### Strobe Key

- Pressing this key places the EVA in the strobe mode for drive shaft balancing and diagnosis

### Numbered Keys

- Used to select one of 10 snapshot tag numbers when recording or playing back information
- Used to enter numeric data required

### RPM/HZ (Zero) Key

- Switches frequency between RPM and Hertz when in the active display

### Record key

- Places EVA in record mode

### A/B (4) Key

- Switches display between A and B inputs

### Playback Key

- Places EVA in playback mode to view vibration information that was previously recorded

### Avg (8) Key

- Switches display between averaging and nonaveraging modes

### Enter Key

- Starts recording once EVA is in record mode and a snapshot tag number has been selected

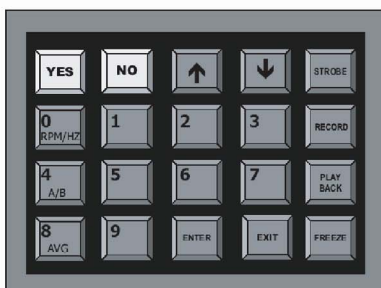
### Exit Key

- Returns screen to active display when in freeze, record, playback or strobe modes

### Freeze Key

- Operates when in active display or during playback
- Pressing it locks display on data at that moment and displays "FRZ" at top of the screen

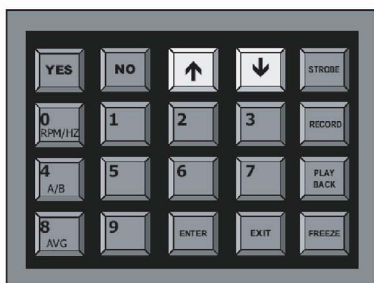
## Pressing Freeze key again will unlock display



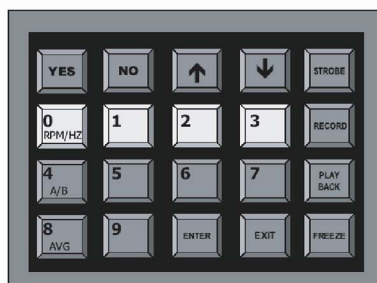
The **YES** and **NO** keys are used to select a filter range when in the strobe balancing mode.



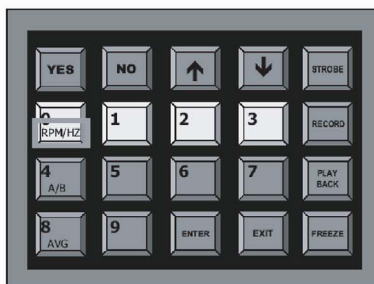
Pressing the **STROBE** key places the EVA in the strobe mode for driveshaft balancing and diagnosis.



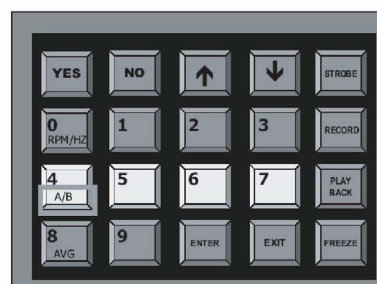
The **UP ARROW** key and **DOWN ARROW** key are used to move through the individual frames of a snapshot during **FREEZE** in the playback mode. Pressing the **UP ARROW** key moves forward one frame; pressing the **DOWN ARROW** key moves back one frame.



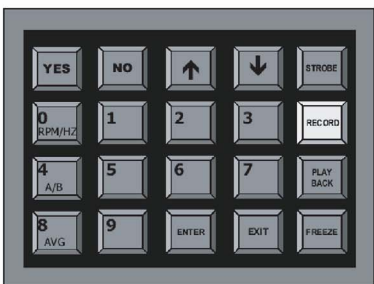
The **NUMBERED** keys 0, 1, 2 and 3 are used to select one of 10 snapshot tag numbers when recording or playing back information.



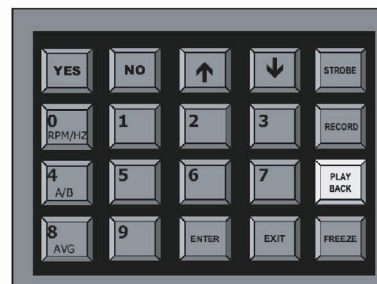
When in the active display, pressing the **RPM/HZ (0)** key switches the frequency between RPM and Hertz.



Pressing the **A/B (4)** key switches the display between the A and B inputs.



Pressing the **RECORD** key places the EVA in the record mode.



Pressing the **PLAYBACK** key places the EVA in the playback mode to view vibration information that was previously recorded.

Figures 5-11 & 5-12, EVA Key Pads

## ASE 4 - Suspension and Steering

## Module 5 - Vibration Correction

**ASE 4 - Suspension and Steering****Module 5 - Vibration Correction**

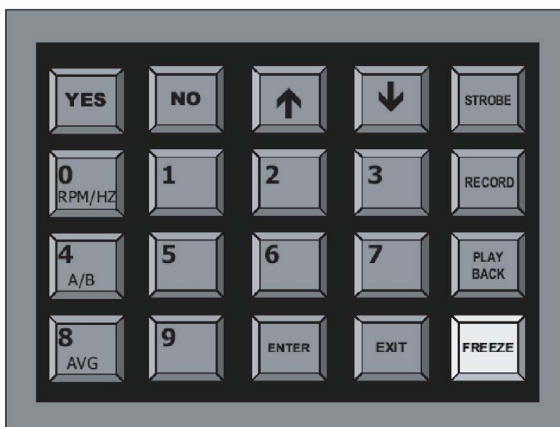
Pressing the **AVG(8)** key switches the display between the averaging and non-averaging modes.



Once the EVA is in the record mode and a snapshot tag number has been selected, pressing **ENTER** starts the recording.



Pressing the **EXIT** key returns the screen to the active display when in **FREEZE**, record, playback, or strobe modes.



Pressing the **FREEZE** key locks the display on the data at that moment and displays "FRZ" at the top of the screen. Pressing the **FREEZE** key again unlocks the display.

*Figures 5-13, 5-14 & 5-15, EVA Key Pads*

## EVA Display Features



Figure 5-16,

The EVA has a Liquid Crystal Diode (LCD) screen, which consists of three columns by four rows of information.



Figure 5-17,

The first row displays the measurements of frequency, either RPM or Hz, which represents Hertz.

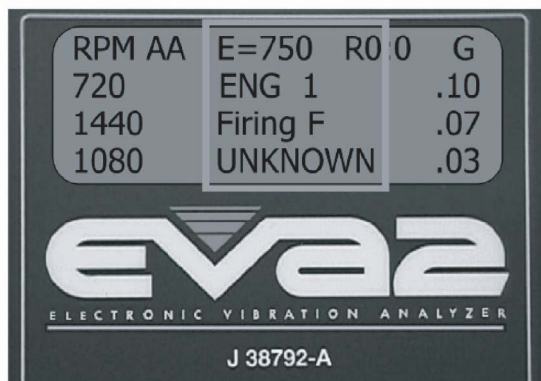
Frequency of vibrations detected is displayed in descending order starting with second row. One to three sources will be identified.



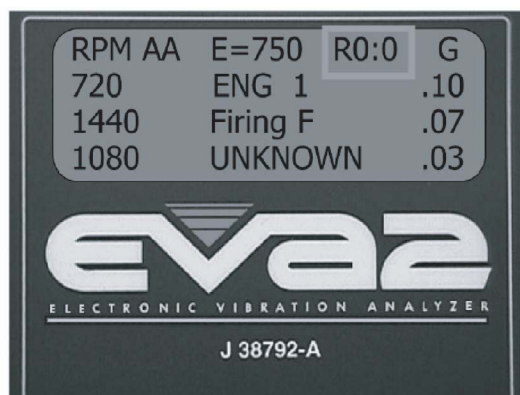
Figure 5-18,

A or B input indicator: Input readings are being received from: Averaging/ Instantaneous Mode: an A for averaging, or an I for instantaneous will precede the A or B input indicator. If averaging mode is selected while using Normal program mode on the EVA2, "AVG" will appear next to A or B in the first row.



**ASE 4 - Suspension and Steering****Module 5 - Vibration Correction***Figure 5-19,*

- Engine speed (E=750) or Vehicle speed (V=65)
- Press Up or Down Arrow to manually adjust value
- Identifies sources of vibrations detected
- Engine 1, 2, 3 or 4 (1st, 2nd, 3rd or 4th order engine concern)
- Firing F (Firing Frequency)
- Prop 1 or 2 (1st or 2nd order propshaft concern)
- Overlap (Overlap of Tire 3 and Prop 1 frequencies)
- Unknown (Vibration source is unknown)

*Figure 5-20,*

- Identification symbol displays during record (R) or playback (P)
- Event and frame numbers
- If event is not selected a "?" appears
- Frame numbers cycle from 0 to 9 during record and playback
- And at the far right of the screen, the actual strength or amplitude of the vibration is displayed

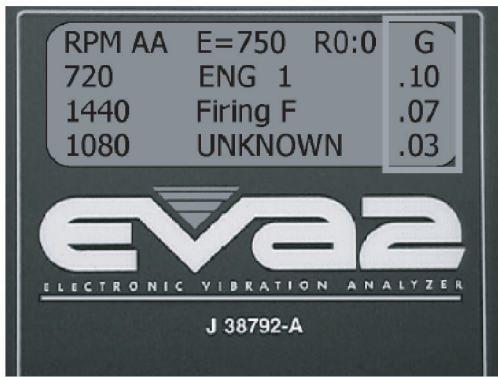


Figure 5-21,

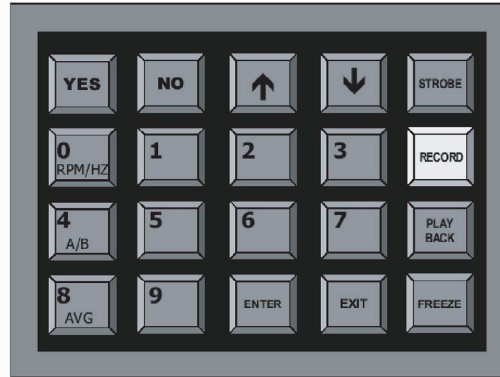


Figure 5-22,

- The Freeze key will lock the display on the data at that moment
- This is particularly useful when conducting an acceleration or deceleration test, where a significant vibration registers only for a very short period
- The EVA can also record vibration data and then play it back at a later time
- The vibration data is recorded as a snapshot. Up to 10 snapshots can be recorded, and each snapshot consists of 10 separate frames
- To record a snapshot, press the Record key

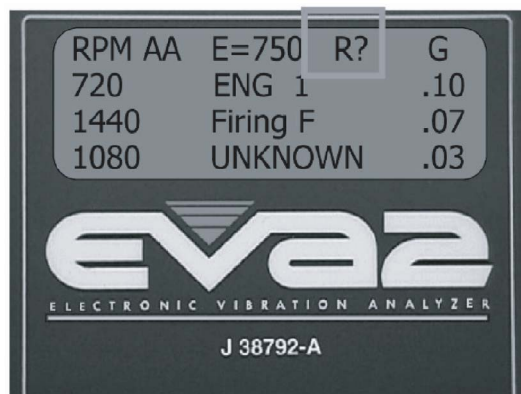


Figure 5-23,

- The Display shows an R with a question mark to request a tag number from zero to nine for the snapshot
- Select numbers for the snapshot, then press Enter key to start recording
- An R and the tag number will appear followed by a series of numbers from zero to nine. These are the individual frames of the snapshot recording
- If a tag number was selected that has already been used to tag a snapshot, existing data stored will be replaced by new data

To playback the recorded data, press the PLAYBACK key



Figure 5-24,

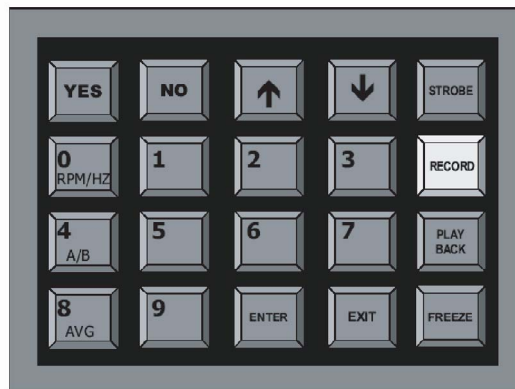


Figure 5-25,

- The Freeze key will lock the display on the data at that moment
- This is particularly useful when conducting an acceleration or deceleration test, where a significant vibration registers only for a very short period
- The EVA can also record vibration data and then play it back at a later time
- The vibration data is recorded as a snapshot. Up to 10 snapshots can be recorded, and each snapshot consists of 10 separate frames
- To record a snapshot, press the Record key



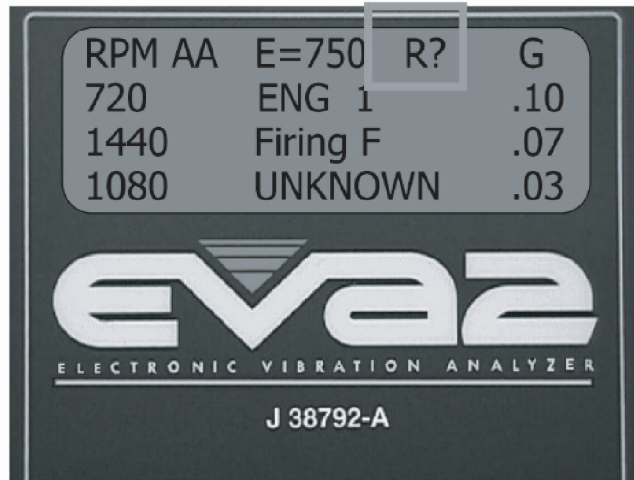
**ASE 4 - Suspension and Steering****Module 5 - Vibration Correction**

Figure 5-26,

- Display shows an R with a question mark to request a tag number from zero to nine for the snapshot
- Select numbers for the snapshot, then press Enter key to start recording
- An R and the tag number will appear followed by a series of numbers from zero to nine. These are the individual frames of the snapshot recording
- If a tag number was selected that has already been used to tag a snapshot, existing data stored will be replaced by new data

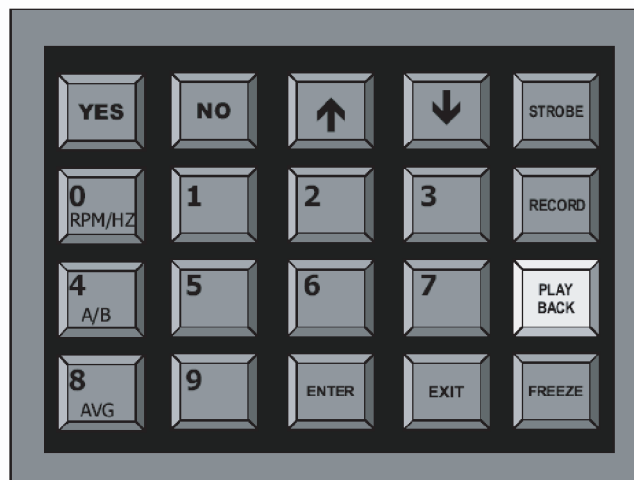


Figure 5-27,

- To playback recorded data, press Playback key
- Display will show a P with a question mark to request tag number of snapshot
- Press Enter

- Snapshot is then played back
- P and snapshot number will appear followed by a series from zero to nine, indicating which frame of the snapshot is being displayed

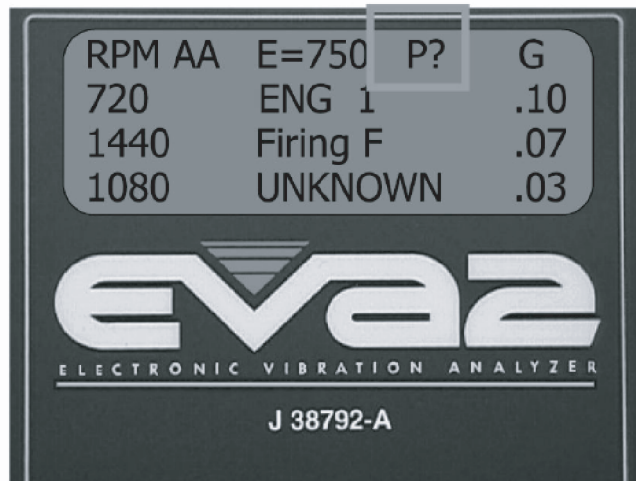


Figure 5-28,

**Notice:**

The EVA will retain any stored data for about 70 hours, after it has been unplugged from a power source.

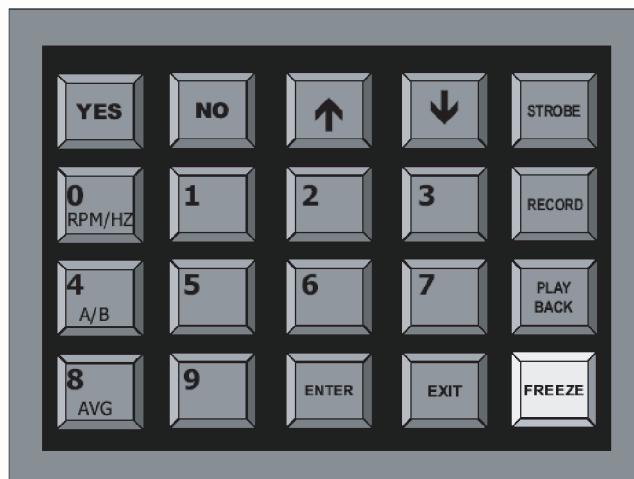
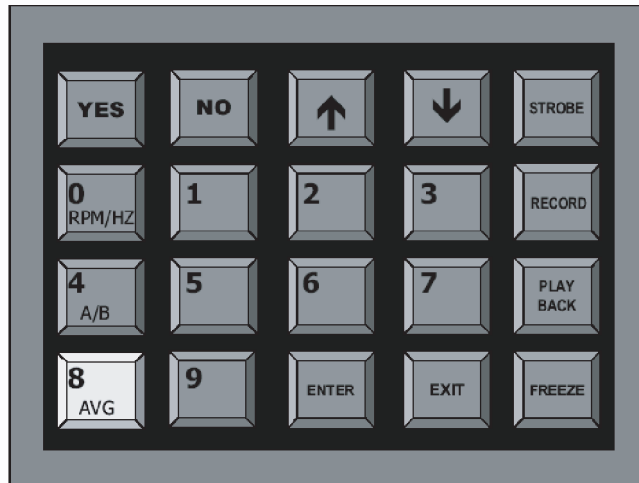


Figure 5-29,

- Anytime during playback, pressing the Freeze key will freeze the display
- Use Up and Down Arrow keys to view individual snapshot frames in forward or backward sequence
- Pressing Freeze key once again will unfreeze display and return to playback mode
- When recording or playback of a snapshot is finished, or if Exit key is pressed, display returns to the active screen

**ASE 4 - Suspension  
and Steering****Module 5 -  
Vibration Correction***Figure 5-30,*

- For normal operation, EVA should be in averaging mode, which averages multiple vibration samples over a period of time. This minimizes the effects of sudden vibrations that are not related to the concern
- In non-averaging mode, EVA is more sensitive to vibration variations. With non-averaging activated, the display is more instantaneous, displaying vibration data at the moment condition exists, and not over a period of time.
- The non-averaging mode is particularly useful when trying to measure a vibration that exists only for a short period of time or when doing acceleration and deceleration tests
- To switch between averaging and non-averaging mode, press AVG key on keypad
- Another special feature of the EVA is strobe balancing

**Notice:**

The phase shift calibration is usually performed at the factory and should not need to be done again under normal use. The sensor calibration is performed to calibrate new or additional sensors, so they work properly with the unit.

**Sensor Calibration**

1. Lay sensor on a flat, stationary surface with embossed UP side facing upward
2. Plug sensor into either A or B input
3. Plug EVA into a 12-volt power supply
4. After display initializes at main menu, press Enter key until live data screen appears on the display
5. Press number 1 key.
6. Press number 2 key, three times.
7. Message "Burning" will appear on display followed by a request to turn sensor over.
8. Turn sensor over and press any key to continue.

**Notice:**

Calibration will be completed in about 5 seconds, and the display will return to the active mode.

## Review

In this session the following was covered:

- Identify a vibration concern
- Determine common causes of vehicle vibration concerns
- Determine if a vibration is acceptable
- Duplicate the concern
- Inspect the tires
- Identify speed-related vibrations
- Classify the frequency of the concern
- Identify vibrations that can be felt or heard
- Determine rotational speed of tires
- Identify the functions and features of the EVA

Student Workbook

**ASE 4 - Suspension  
and Steering**

**Module 5 -  
Vibration Correction**



## Lesson 3: Smart EVA and EVA2 Program

### Objective

Explain the differences between the EVA and EVA2 program.

### Introduction

The Smart EVA and EVA2 programs are designed to perform targeted frequency calculations on a suspected vibration source.

### Target Frequency Calculations

- Tire size, axle ratio, number of cylinders, vehicle speed, and engine speed are used to generate a table of frequencies that could occur on that vehicle
- The sensor input is compared to the table. If input frequency falls within a range on the table, EVA will display a suspected source of the vibration
- In most instances, Smart Eva and EVA2 cartridge will replace need for vibration worksheets previously used when using the tool

### Primary Mode Functions

- Auto Mode, which includes enhanced test input and calculation functions
- Normal Mode, in which the EVA2 operates as if the original EVA cartridge is installed
- Smart Strobe, which features a user-selectable timing light firing frequency

### New Menu Navigation Functions

- Press Exit key once to move back one screen; press it twice to move back to the opening menu.
- Press Up Arrow key to move cursor to the left; press Down Arrow key to move cursor to the right.

## EVA2 Auto Mode RPM

The Smart EVA and EVA2 Auto Mode is a program designed to consider a suspected source of vibration, such as engine or vehicle speed.

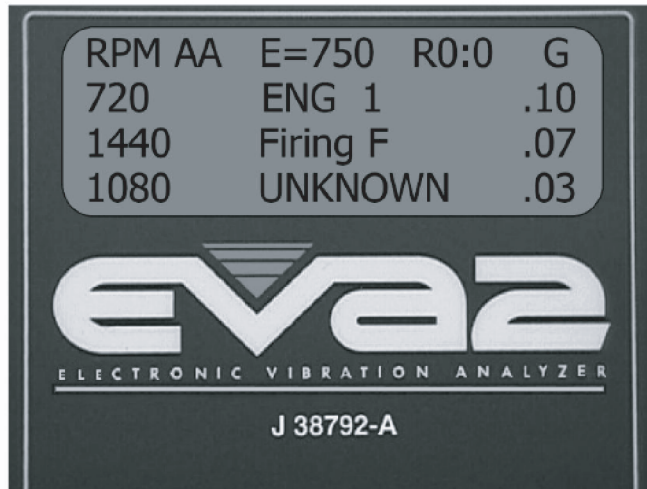
Use it in conjunction with baseline data, such as tire size, axle ratio, RPM, and so on, to identify a suspected source of vibration. Prior to using the EVA, it should be determined if the source of vibration is engine or driveline related by performing the Slow Acceleration, Neutral Coast-Down, and Downshift tests according to the Service Information procedures.

### To use EVA2 Auto Mode:

1. Select Auto Mode from the main menu.
2. Select suspected source of vibration, either engine RPM or vehicle speed.
3. Move cursor to appropriate number of cylinders and press Enter key
4. Use number keys to enter engine RPM where vibration is at a maximum level, and press Enter key.
  - Select incremental step to increase or decrease RPM by pressing Enter key
  - You will need to press Enter several times to navigate to the active data screen now displayed
  - On the active data screen, press Up or Down Arrow key to adjust on screen RPM to match actual engine RPM

## ASE 4 - Suspension and Steering

## Module 5 - Vibration Correction

**ASE 4 - Suspension and Steering****Module 5 - Vibration Correction***Figure 5-31,*

- Data is displayed as revolutions per minute
- Vibrations detected are displayed in descending order beginning with line two
- Amplitude of each signal is displayed in number of G forces
- Data displayed is averaged as indicated by the first A displayed on the screen
- Second A displayed indicates data is received through input A
- Engine RPM is displayed next to E displayed on screen. This RPM value needs to be adjusted to actual engine RPM, using Up or Down Arrow keys
- In this example, an R is displayed on screen indicating EVA is recording. If EVA was in playback mode, a P would be displayed
- Two numbers, zeros in this case, are separated by a colon and indicate event tag number and specific frame number. This only occurs during record or playback modes
- This example indicates that a first-order engine vibration has the highest amplitude and should be resolved first
- One to three sources of vibration could be identified here:
  - Engine 1, 2, 3 or 4, indicating first, second, third or fourth-order engine concern
  - Firing F, which indicates vibration due to firing frequency
  - Unknown, which indicates vibration source is unknown



While viewing the active data, brief descriptions of recommended diagnostic steps are available:

- Press Freeze key, move cursor to select system and press Enter key
- Press Up or Down Arrow keys to view tests
- Press Exit twice to return to active data display again
- Press Freeze key then Strobe key to view table
- You will see a table of ranges for sources of vibration at RPM:
  - Press Up or Down Arrow keys to view ranges
  - Press Exit key twice to return to active data display

A vehicle system is displayed only if the vibration is within the frequency range calculated for a specific vehicle system.

- Different RPMs produce different frequency ranges
- If the vibration falls within the unknown category, further diagnosis may be required to determine the source

### EVA2 Auto Mode MPH

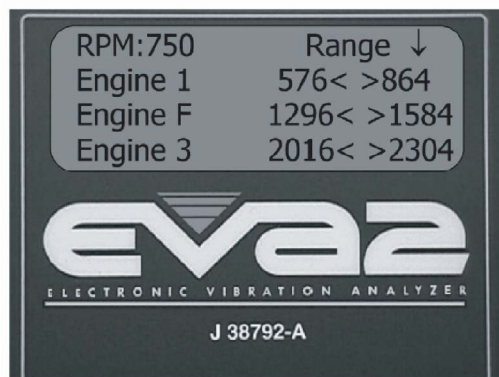


Figure 5-32,

- As before, from the main menu, select Auto Mode and press the Enter key.
- At the next screen, select vehicle speed and press the Enter key.
- This information can be entered in one of three ways: revolutions per second (RPS) at 5 miles per hour (MPH), database, and manual entry.

If RPS at 5 MPH is selected:

- Manual entry of RPS at 5 MPH for vehicle's tires
- This information must be looked up using tire chart in vehicle Service Information and entered using number keys

If database is selected, a series of screens will be consecutively displayed so the EVA2 can do the calculations.

- Select either passenger car, light truck or miscellaneous, and press Enter key
- Scroll through list of tire sizes and select tire size that is on the vehicle, and press Enter key

If manual entry was selected when tire size information was initially requested, a series of screens will appear to manually enter the information:

- Verify width embossed in the tire and enter that size manually using the number keys, and press the Enter key
- Verify this on vehicle tire and manually enter it using number keys. Press Enter key
- Using number keys, enter rim size and press Enter key
- Select appropriate configuration and press Enter key
- Select RWD

The next screen that appears requests axle ratio information.

- This screen will not be displayed if front wheel drive configuration was selected, as axle ratio is not applicable
- Scroll through list of axle ratios and select appropriate axle ratio for vehicle and press Enter key

The next screen requests the vehicle speed units.

- Select either miles per hour or kilometers per hour and press Enter key
- Enter vehicle speed at which vibration is felt using number keys, and then press Enter key
- Enter 65 mph
- Select incremental step to increase or decrease vehicle speed and press Enter key

As the test runs, the vehicle speed must be manually adjusted to match the actual vehicle speed.

Press the Up Arrow key or Down Arrow key to adjust the vehicle speed on the live data screen to match the actual vehicle speed.

**Remember:**

The EVA is not hooked to the electrical system of the vehicle. You must manually enter vehicle speed.

## EVA Screen Data

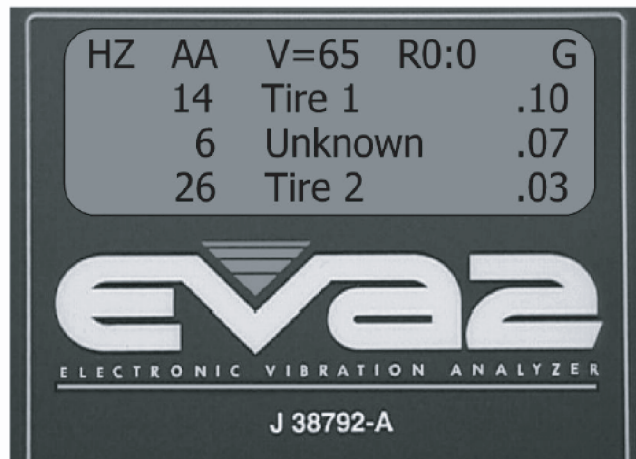


Figure 5-33,

## EVA Screen Data Review

- Data is displayed in Hertz
- Vibrations detected are displayed in descending order beginning with line two
- Amplitude of each signal is displayed in number of G forces
- Data displayed is averaged, as indicated by the first A displayed on screen
- Second A displayed indicates data is received through input A
- Vehicle speed is indicated next to the V displayed on screen. This speed is in miles per hour or kilometers per hour as previously selected. Press Up or Down Arrow keys to manually adjust this figure to match the actual vehicle speed.
- In this example, an R is displayed on screen indicating EVA is recording. If EVA was in playback mode, a P would be displayed
- Two numbers, zeros in this case, are separated by a colon and indicate event tag number and specific frame number. This occurs only during record or playback modes

This example indicates that a first-order tire vibration has the highest amplitude and should be resolved first

Up to three of the four types of sources could be displayed here, and particular attention must be paid to the magnitude of the vibration

Tire 1, 2 or 3 indicating a first, second or third tire/wheel concern

Prop 1 or 2, indicating a first or second-order propshaft concern

Overlap, indicating an overlap of third-order tire and first-order propshaft frequencies

Unknown, indicating the vibration source is unknown

### Diagnostic Steps

- Press Freeze key, move cursor to select system and press Enter key
- Press Up or Down Arrow keys to view tests
- Press Exit key twice to return to active data display

Additionally, a table of ranges for sources of vibration at an RPM is available:

### Source Range Tables

- Press Freeze key, then Strobe key to view table
- Press Up or Down arrow keys to view ranges
- Press Exit key twice to return to active data

A vehicle system is displayed only if the vibration is within the frequency range calculated for a specific vehicle system.

Different speeds produce different frequency ranges.

- If vibration falls under overlap category, completion of worksheets may be required to determine source
- If vibration falls within unknown category, further diagnosis may be required to determine source

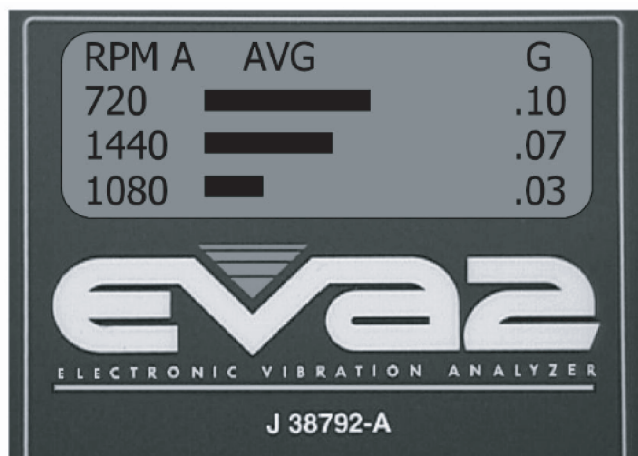


Figure 5-34,

The second mode is normal mode. Normal mode is a program that displays the three most intense vibrations detected from an engine or vehicle speed source.

This mode is not available when using the Smart EVA software cartridge.

- Select Normal Mode from main menu and press Enter
- Vibrations detected will be displayed on an active data screen

### EVA Smart Strobe Introduction

- Smart Strobe mode enables complete control of frequency at which strobe light will flash.
  - This makes it an excellent tool for identifying speed that objects are rotating at, which is helpful in determining source of a vibration.
1. Clip inductive pickup of the timing light to the loop hanger on EVA2 and connect timing light to a 12-volt power source.
  2. Select Smart Strobe from main menu and press Enter key.
  3. Mark object suspected of causing concern.
  4. Using number keys to manually enter an initial strobe frequency between 10 and 200 Hertz.

**Remember that Hertz is revolutions per minute divided by 60.**

5. Press RPM/Hz key to toggle to RPM.

#### Caution:

**To avoid personal injury when performing vibration or balance checks, stay clear of rotating components and balance weights.**

**ASE 4 - Suspension and Steering**

**Module 5 - Vibration Correction**

6. Hold engine RPM steady at suspect speed.

- Point strobe light at rotating component and press strobe light trigger
- Press EVA Up or Down Arrow keys to manually adjust strobe frequency, until only one mark is seen and mark on rotating component appears stationary
- Strobe adjustment screen will be displayed on EVA
- To adjust increments, press any number key to adjust increments by that value
- To adjust increments by 10 times the value of the number pressed, press Strobe key first, then number key

**Notice:**

Once the mark on the rotating component appears to be stationary, the frequency of the strobe can be read on the screen. If the strobe frequency matches a vibration frequency received during auto mode testing, the rotating component is the source of the vibration concern.

### **Driveline Balancing Using the EVA**

**Notice:**

Do not use Smart Strobe for balancing.

The strobe function used for driveline balancing can be activated from the Auto Mode active data display or normal mode.

1. From the EVA main menu, select Auto Mode and press Enter key. Normal Mode may be selected if using EVA2.
2. Press Strobe key.
3. Select a filter range in which the frequency falls.

This step provides three different ranges, each with its own screen:

- First filter screen is low range, 35 to 45 Hz.
- Press Yes key to accept this range or No key to view next range
- Next filter is medium range, 45 to 55 Hz.
- Press Yes key to accept this range or No key to view final range
- Final filter is high range, 55 to 65 Hz.
- Press Yes key to accept this range or No key to return to first range
- Once a filter has been selected, the strobe will become active.

**Notice:**

At this point, driveline balancing would be completed according to the EVA2 directions or as you previously did with the original EVA tool. There are now three filter ranges on the EVA2, instead of two filter ranges on the Smart EVA to more closely pinpoint the frequency for balancing.

**Review**

- Identify the concern
- Classify the vibration
- Match frequency to component
- Describe tire and wheel assembly vibrations
- Describe EVA functions
- Describe EVA2 Program

You should now be able to identify vibration concerns.

## Lesson 4: Vibrate Software

### Objective

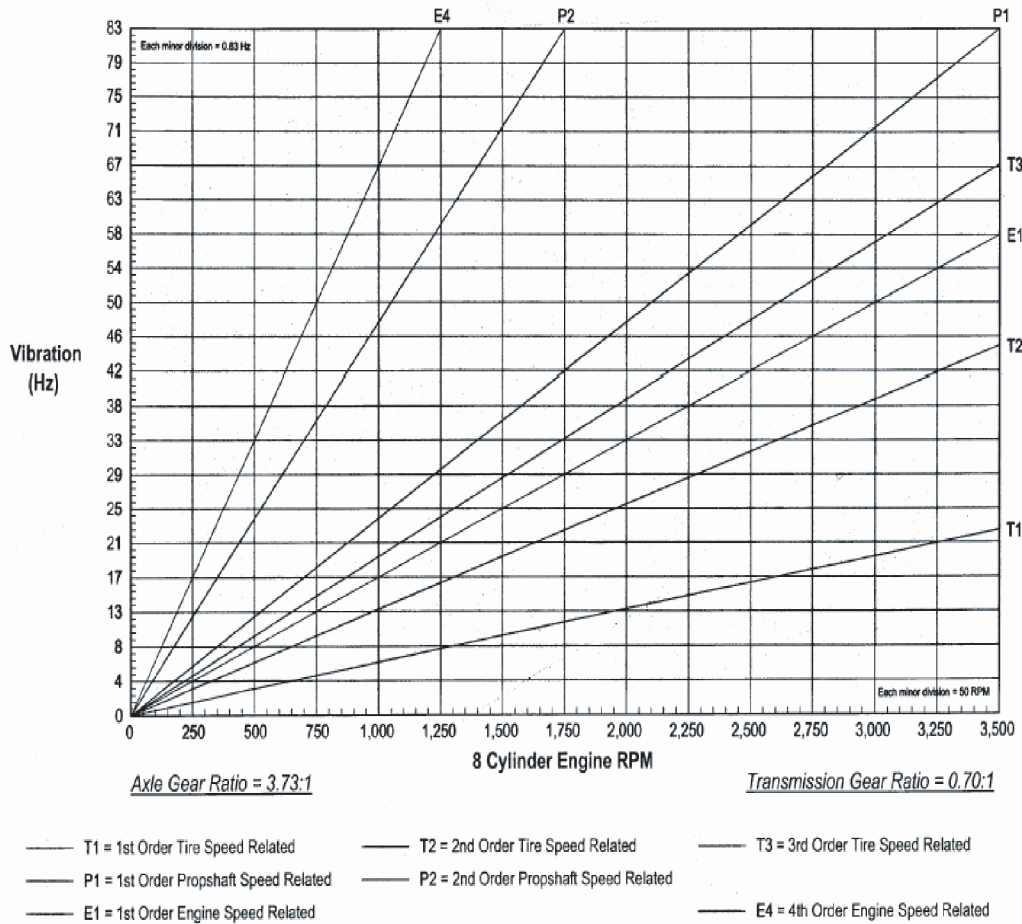
Describe how to use vibrate software.

### Introduction

- The J37892-VS computer software package is a tool that helps service technicians diagnose a vibration concern.
- The software is designed as a companion for the J37892 Electronic Vibration Analyzer (EVA).
- This method of vibration diagnosis works on all vehicles regardless of:
  - Manufacturer
  - Make
  - Model
  - Engine size or type
  - Transmission
  - Axle
  - Tire size
- J37892-VS computer software calculates rotational speeds of each component and graphically represents these speeds on a computer screen and on a printed graph.
- Printed graph is for a technician to use while test-driving a vibrating vehicle.
- When vehicle's vibration is present, technician records vibration frequency and engine RPM on graph.
- There is a point on the graph where vibration frequency reading and engine RPM reading intersect. This point should be on, or very close to, a plotted line on the graph.
- Plotted line indicates specific component group causing the vibration.
- Technician can diagnose which component in the component group is causing the vibration by using diagnostic procedures outlined in Help file and vehicle manufacturer's Service Information.
- After starting the software program, a Front-Wheel-Drive prompt is displayed.



## Vibration Diagnosis Worksheet



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4.0.0238

Figure 5-35,

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**ASE 4 - Suspension and Steering**

**Module 5 - Vibration Correction**



- Select either Yes or No button.
- By default, No button will be selected if Enter key is pressed.
- Vibrate software uses this information to determine if it needs to perform driveline rotational speed calculations.
- Next, a prompt to enter final drive axle gear ratio is displayed.
- To see a list of drive axle gear ratios for each vehicle manufacturer, press Help button.
- Help file displays a list of vehicle manufacturers.
- A list of final drive axle gear ratios is displayed.
- Use GM production option code to determine gear ratio.



Figure 5-36,

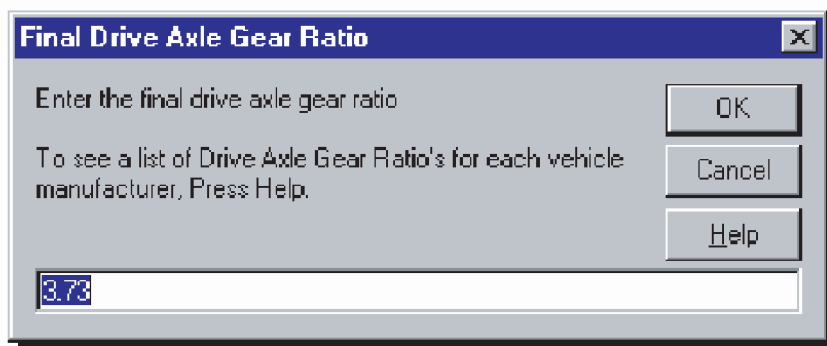


Figure 5-37,

- Next, a prompt to enter transmission gear ratio is displayed.

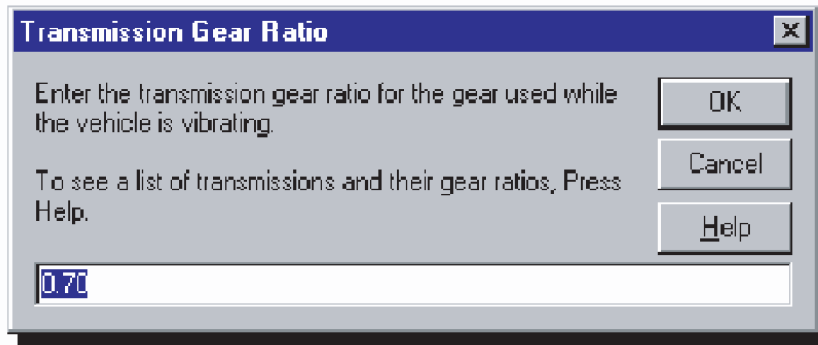


Figure 5-38,

- To see a list of transmission gear ratios for each vehicle manufacturer, press Help button
- Use GM production option code to determine transmission used, and then determine gear ratio for gear used while vehicle is vibrating.
- Finally, a prompt to enter number of engine cylinders is displayed.
- Enter number of cylinders in the engine.

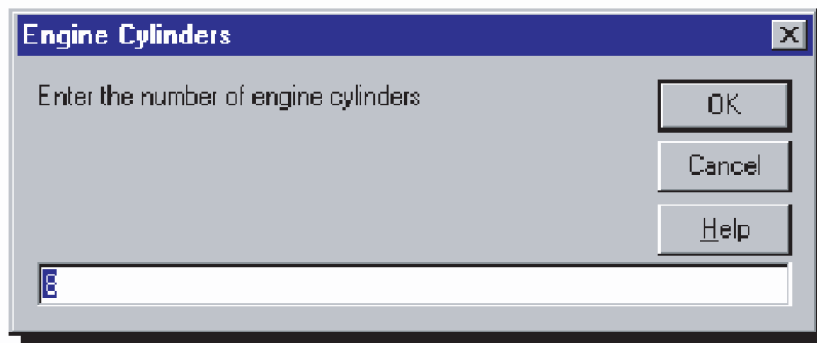


Figure 5-39,

- Software program uses this information to calculate engine speed-related vibration frequencies.

## Road Testing

- Road test instructions are displayed next.
- Print this page by selecting the Print button, and then close the Help file by selecting Exit button.
- Take a printed copy of the road test instructions with you on the road test.

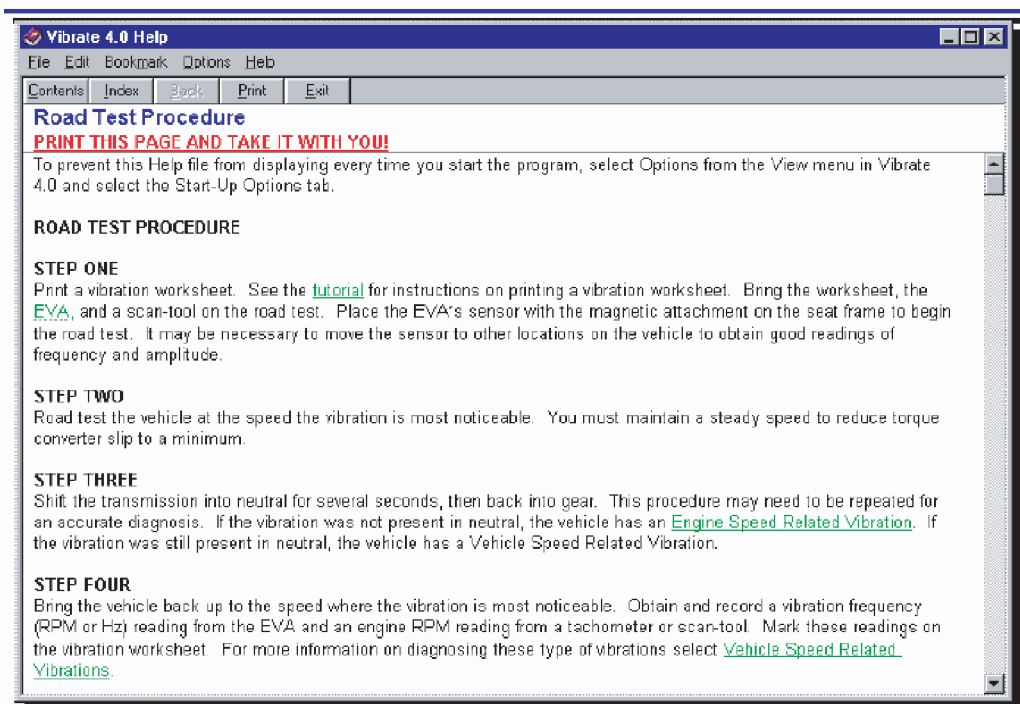


Figure 5-40,

## Vibration Worksheet

- Vibrate software program performs several calculations, and then displays a customized vehicle-specific vibration worksheet on the computer screen.
- Press Print button located at upper right corner of the screen to print vibration worksheet. This worksheet is required on the road test.

- Each line on the worksheet represents a specific group of rotating components on the vehicle.
  - Red lines represent Tire Speed-Related vibrations.
  - Blue lines represent Propshaft Speed-Related vibrations.
  - Green lines represent Engine Speed-Related vibrations.
- Each line on the worksheet is identified by a combination of letters and numbers. This identifier is displayed in a box at the end of the line.
- Lines displayed and identifiers used on worksheet will vary from vehicle to vehicle, based upon number of engine cylinders and gear ratios used in transmission and drive axle.
- Each identifier is described in the legend at bottom of screen.
  - T1 represents a first-order tire speed-related vibration
  - T2 represents a second-order tire speed-related vibration
  - T3 represents a third-order tire-speed-related vibration
  - P1 represents a first-order propshaft speed-related vibration
  - P2 represents a second-order propshaft speed-related vibration
  - E1 represents a first-order engine crankshaft speed-related vibration
  - E4 represents a fourth-order engine crankshaft speed-related vibration

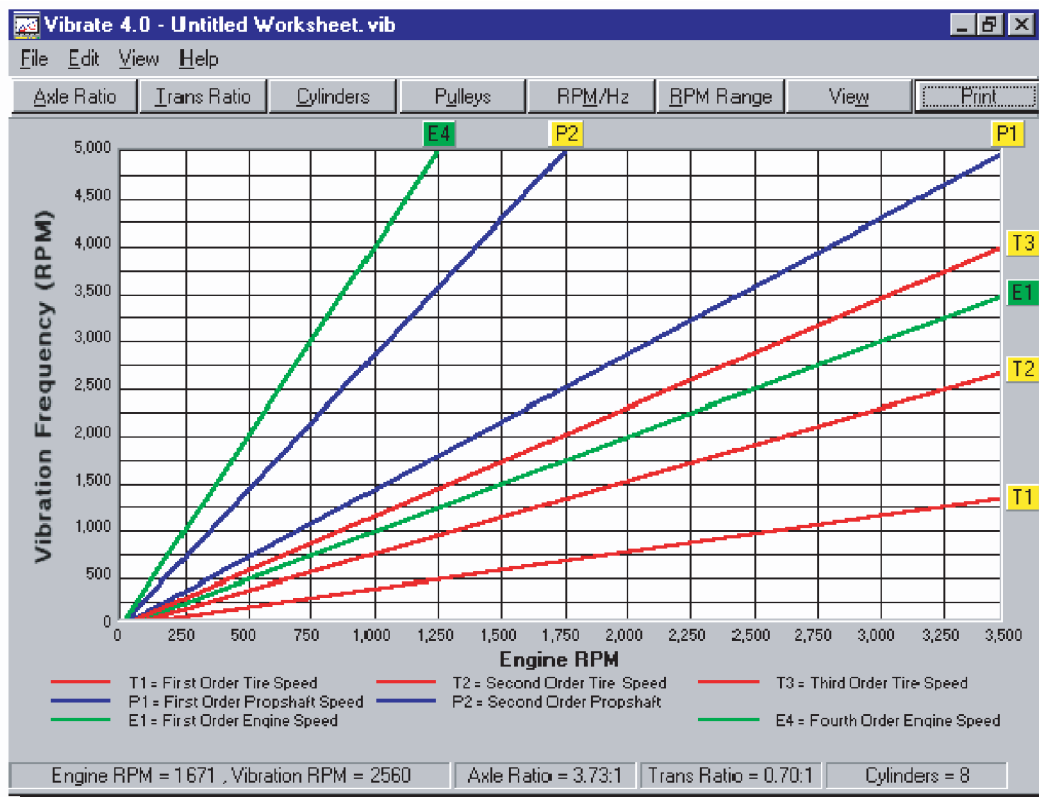


Figure 5-41,

The purpose of the road test is to determine the type of vibration and order of vibration frequency.

Most vehicle vibrations can be classified into two categories:

**Vehicle-Speed-Related Vibrations.** A vehicle speed-related vibration usually occurs at the same vehicle speed, regardless of engine RPM. This type of vibration cannot be detected with the vehicle stopped.

**Engine-Speed-Related Vibrations.** An engine speed-related vibration usually occurs at the same engine RPM speed, regardless of vehicle speed. This type of vibration can usually be detected with the vehicle stopped, although sometimes it may only show up under a load.

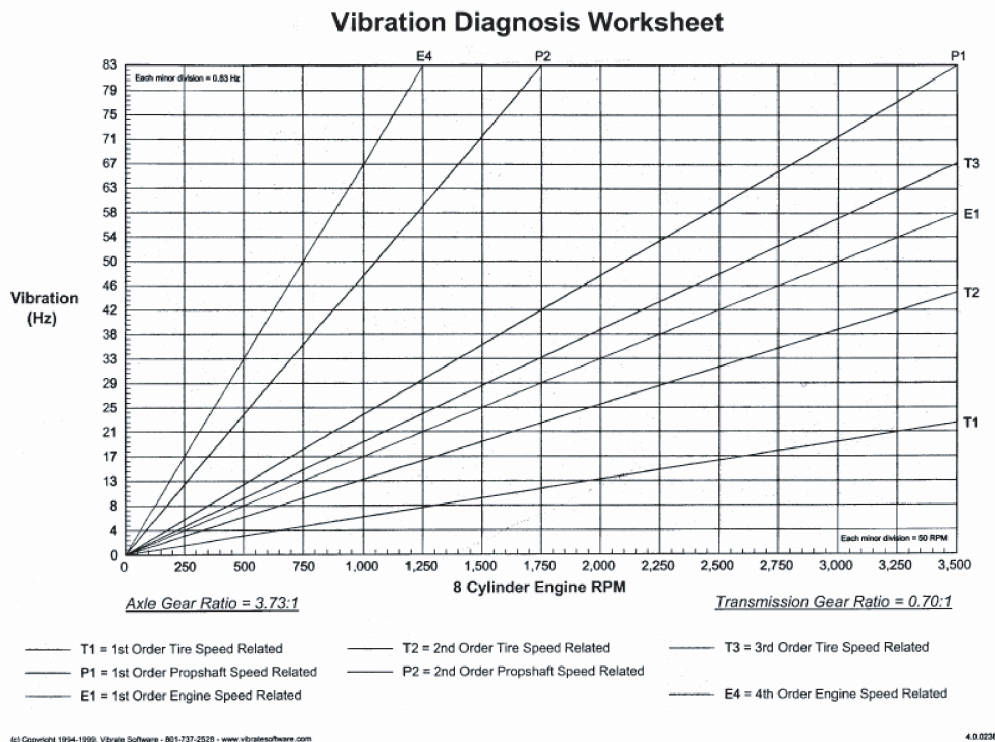


Figure 5-42,

## Road Testing Precautions

- When road testing a vehicle, it is important that the following precautions are taken:
  - Inspect vehicle to insure it is safe to drive.
  - Road test vehicle on a smooth, level road.
  - A steady throttle must be held to take accurate readings on vehicles equipped with an automatic transmission.
  - Take several measurements at different vehicle speeds to verify type of vibration.

## Road Test Procedure

1. Take vibration worksheet, the EVA, and a scan-tool on the road test.
2. Road test vehicle at the speed vibration is most noticeable. Maintain a steady speed to reduce torque converter slip to a minimum.
3. Shift transmission into neutral for several seconds, then back into gear. This procedure may need to be repeated for an accurate diagnosis.
  - If vibration was not present in neutral, vehicle has an Engine-Speed-Related Vibration.
  - If vibration was present in neutral, vehicle has a Vehicle-Speed-Related Vibration.
4. Bring vehicle back up to speed where vibration is most noticeable.
5. Obtain and record a vibration frequency (RPM or Hz) reading from the EVA and an engine RPM reading from a tachometer or scan-tool.
6. Mark these readings on printed vibration worksheet.

## Matching Vibration Frequency to Component RPM

After road testing, draw a vertical line on printed worksheet that corresponds with engine RPM recorded in Step 4 of road test.

Draw a horizontal line across printed worksheet that corresponds with vibration frequency recorded in Step 4 of road test.

The point on the worksheet where the two lines intersect should be on or very close to one of the component group lines.

## Belt-Driven Accessory Vibrations

If a belt-driven accessory is suspected of causing a vibration and it is not obvious which accessory is causing the vibration, you can calculate the rotating speed of each pulley using vibrate software.

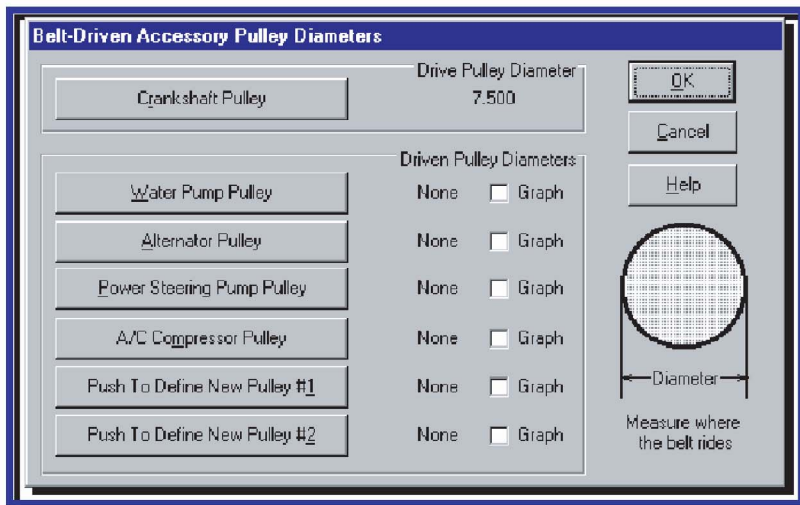


Figure 5-43,

## Function Bar



Figure 5-44, Function Bar

The function bar is located at the top of the screen and allows the user to select many different display options related to the vibration worksheet.

- **Axle Ratio** - Enter final drive axle gear ratio.
- **Trans Ratio** - Enter Transmission gear ratio. This must be the gear used while vehicle is vibrating.
- **Cylinders** - Enter number of engine cylinders.
- **Pulleys** - Enter pulley diameters of the engine's belt-driven accessories.
- **RPM/HZ** - Allows user to toggle between RPM and Hz modes of display on the graph.
- **RPM Range** - Allows user to change engine RPM range on screen. This is useful when a vibration frequency is higher than screen is displaying.
- **View** - Allows user to view Vehicle-Speed-Related Vibrations, Engine-Speed-Related Vibrations, or both on the screen.
- **Print** - Allows user to print current vibration graph.

## Mouse Functions

- Left mouse button is used to select objects such as:
  - Buttons
  - Check boxes
  - Menus
- Left mouse button can also be used to make a cross-hair mark on the graph for on-screen diagnostics.
- Right mouse button clears the cross-hair marks made with the mouse.



## Lesson 5: Wheel Assembly Vibrations

### Objective

Describe Tire and Wheel Assembly Vibrations.

### Symptoms

Tire/wheel assembly vibrations are indicated by the following symptoms:

- Always vehicle-speed related
- Will feel like a shake, usually in steering wheel or seat
- At low speeds (5 to 35 mph) customer may complain of a "waddle"
- Frequency will correspond to first-order of tire rotation
- Vibration will be in the 10 to 20 Hz range, depending on speed of concern and size of tire
- First-order tire vibrations rarely produce noise
- Exception: If tires display irregular tread patterns or flat spots causing a "growling" or "slapping" noise

### Notice:

Tire/wheel vibrations felt in the steering wheel are most likely related to the front tire/wheel assemblies. Those felt in the seat or floor are most likely related to the rear tire/wheel assemblies.

## Causes of Tire and Wheel Vibrations

- First-order tire and wheel vibrations are usually result of the following conditions:
  - Excessive radial or lateral runout (should be corrected first)
  - Excessive imbalance
  - Excessive radial or lateral force variation
- All first-order tire and wheel vibrations must be eliminated step-by-step to attain a set of tires free from vibration-causing elements.

### Notice:

If the vehicle has been sitting in one place for a long time, flat spots may exist at the point where the tires were resting on the ground.

These flat spots will affect the runout readings and should be eliminated by driving the vehicle long enough to warm up the tires.

Do this before any runout measurements are taken.

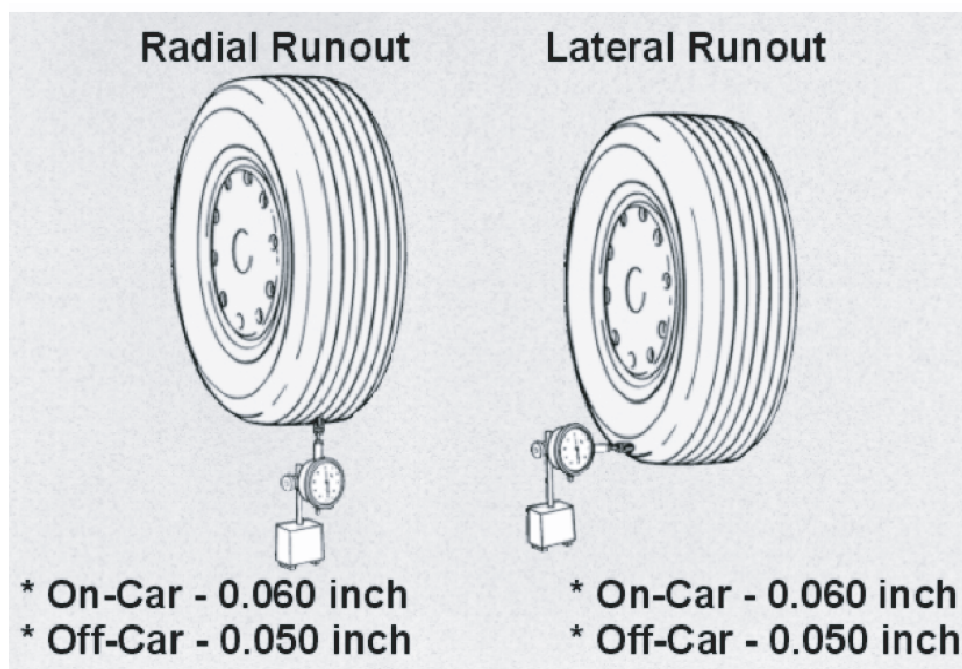


Figure 5-45,

The following checks should be performed before removing the tire/wheel assemblies from the vehicle:

- The distance from edge of rim to concentric rim-locating ring on tire should be equal around entire circumference
- Tire should be remounted if beads are not seated properly
- Measure on-vehicle runout using procedure from vehicle service manual
- Spec: 1.552 mm (0.060 in)
- If on-vehicle runout is within specification, check balance of tire and wheel assemblies

If on vehicle runout is out of specs, then measure the tire/wheel runout off the vehicle keeping the following points in mind:

- Mark location of wheel relative to studs and specific location on vehicle (LF, LR, etc.)
- Measure using procedure found in vehicle Service Information
- Spec: 1.27 mm (0.050 in)

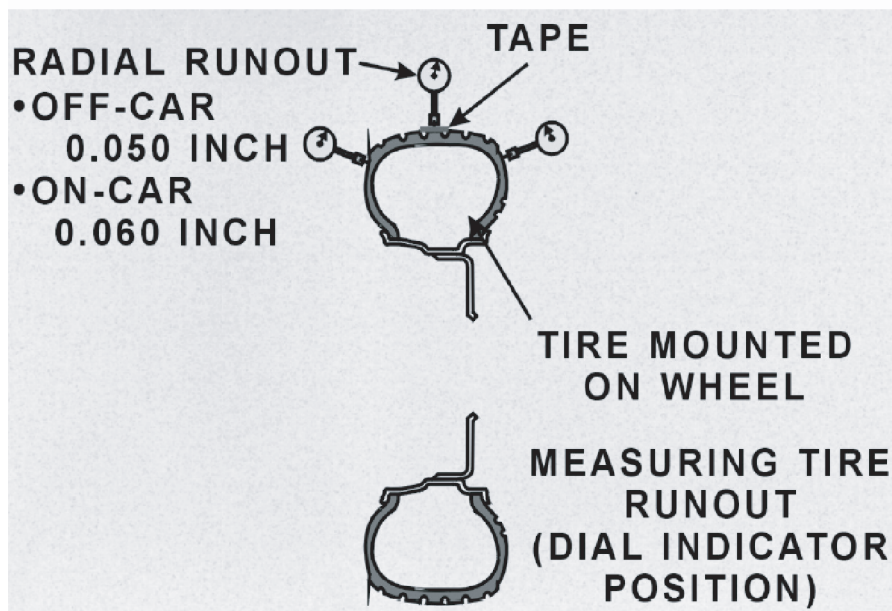


Figure 5-46, Tire Assembly Runout

**ASE 4 - Suspension and Steering****Module 5 - Vibration Correction****Notice:**

If the tire and wheel assembly runout cannot be brought within tolerance, dismount the tire from the wheel and measure wheel runout.

**Measuring Wheel Runout**

- Measured in same fashion as tire runout
- Measured more accurately on inside bead area of wheel
- Ignore any jumps or dips due to paint drips, chips, or welds
- Measure both inboard and outboard flanges

**Runout Tolerances**

## Steel wheels

- Radial runout - 0.040 inch
- Lateral runout - 0.045 inch

## Aluminum wheels

- Radial runout - 0.030 inch
- Lateral runout - 0.030 inch

**Notice:**

The tolerances listed are to serve as guidelines.

- If wheel is beyond tolerance, wheel must be replaced
- If wheel is within tolerance, but tire/wheel assembly runout cannot be corrected, the tire must be replaced
- Always measure runout of a tire/wheel assembly when wheel and/or tire are replaced
- Refer to the wheel code that is stamped next to the valve stem

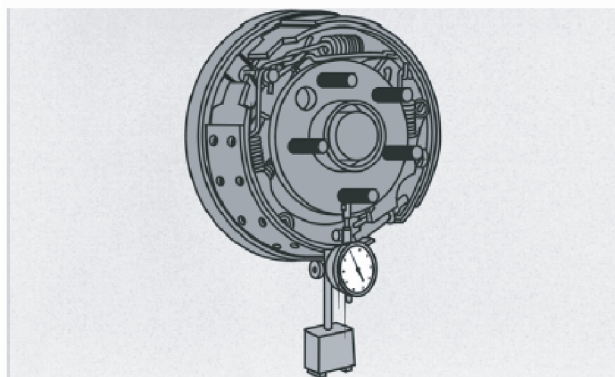


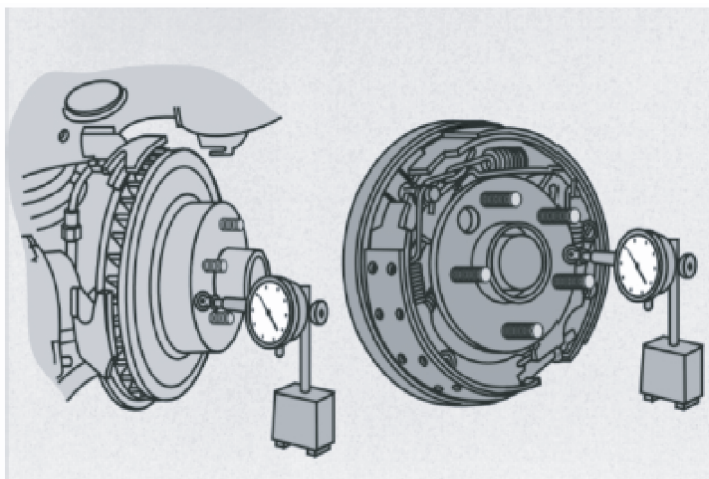
Figure 5-47, Measuring Wheel Stud Runout

**Notice:**

Large differences in runout measurements from on-vehicle to off-vehicle may result from components other than the tire and wheel assemblies

**Causes**

- Either stud circle runout or hub flange runout
- A mounting issue may exist between wheel and vehicle
- Wheel stud runout (stud circle runout) should be checked whenever off-vehicle radial runout and on vehicle radial runout are significantly different, and previous attempts to correct tire/wheel vibration have failed



*Figure 5-48, Axle Flange Runout*

**Axle Flange Runout**

- Hub or axle flange runout should be checked when wheel and tire lateral runout occur on vehicle, and do not occur in off-car testing
- Wheel stud runout and hub/axle flange runout should be checked and corrected, as directed by vehicle Service Information.

## Hub/Rotor/Drum Runout

On-vehicle runout can be affected by an imbalance in the hubs, rotors, or drums. To correct these causes, it may be necessary to perform on-vehicle, high-speed balance or replace suspected components.

- Perform mounting inspection, as described using Service Information
- Checks balance of hubs, rotors, and drums
- No set tolerance for rotor or drum imbalance
- Suspected drums/rotors should be replaced
- New rotor should be checked for imbalance in same manner
- Some sensitive vehicles may still be affected if runout measurements are within tolerance but are marginal

### Notice:

It is always advisable to reduce runout to as little as possible to attain optimum results under all conditions.

## Force Variation

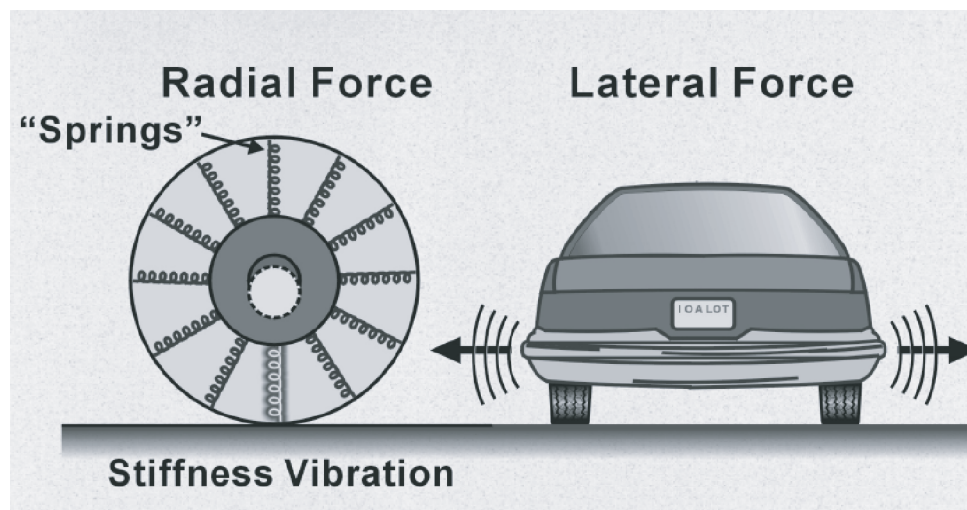


Figure 5-49,

- Force variation is a radial or lateral movement of the tire/wheel assembly which appears as runout
- Some tire/wheel assemblies may exhibit vibration causing a force variation, even though they are within runout and balance tolerances



**Notice:**

Ensure that the tire/wheel assembly runout is at an absolute minimum to minimize force variation as a factor in tire/wheel vibration.

**Tire/Wheel Imbalance**

There are two types of tire/wheel balance: static and dynamic.

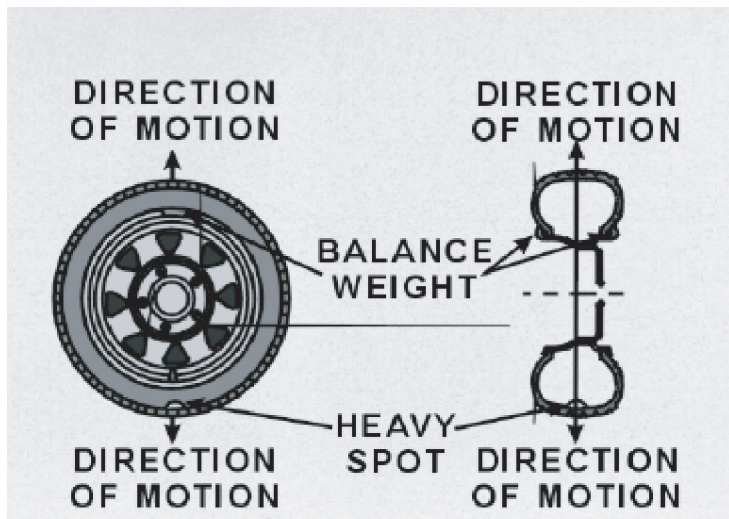


Figure 5-50, Static Balance

**Static Balance**

Static balance, also called single-plane balance, affects the distribution of weight around the wheel circumference.

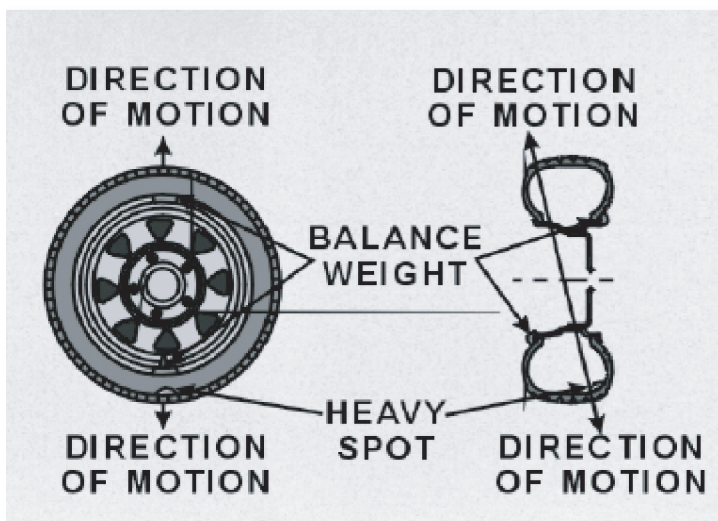


Figure 5-51, Dynamic Balance

**Dynamic Balance**

Dynamic balance, or two-plane balance, affects the distribution of weight on each side of the tire/wheel centerline.

**Notice:**

When balancing aluminum wheels, plastic-coated (polyester) wheel weights should be used to prevent cosmetic damage and corrosion on the aluminum surfaces.

### ASE 4 - Suspension and Steering

### Module 5 - Vibration Correction

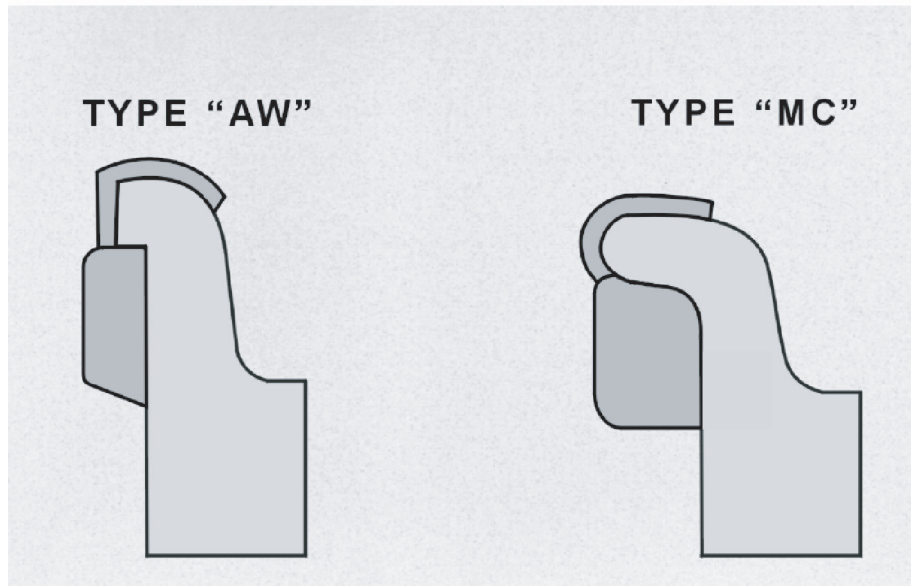


Figure 5-52, Plastic-Coated Wheel Weights

- Type AW is generally used on J, L, N, Y and some A, F and B platforms
- Type MC is used on all other vehicles and light-duty trucks
- Use a plastic or Teflon-tipped hammer when installing wheel weights to minimize possibility of cracking protective coating
- After-market wheels, especially those incorporating universal lug patterns, should be regarded as potential sources of runout and mounting concerns.
- Use correct coated weights on aluminum wheels

Once all four tire/wheel assemblies have been corrected for runout and imbalance:

- Reinstall them on vehicle
- Double-check on-vehicle runout
- Evaluate vehicle at concern speed and note if vibration has been corrected



## On-vehicle Balance Procedure

If checking and/or correcting these components off the vehicle is not possible or does not correct the vibration:

- It may be necessary to balance tire/wheel assemblies while they are mounted on vehicle using an on-vehicle, high-speed spin balancer

### Differences: On/Off Vehicles Balance

- Assemblies can be balanced off the vehicle or on the vehicle
- An off-vehicle balance is the best choice, because balance is not affected when it comes time to rotating tires
- Also, off-vehicle balancers are generally more accurate than on-vehicle balancers, and can perform dynamic as well as static balance
- Balance tire according to equipment manufacturer's instructions

### Notice:

Placing the EVA sensor on the fender of the vehicle while checking the on-vehicle balance is an excellent visual indication of the amplitude of the vibration, and the effect that the balance has on it.

Evaluate condition after checking on-vehicle balance to determine if vibration has been eliminated.



*Figure 5-53, Determining Vibration Amplitude*

## Lesson 6: First-Order RWD Driveline Vibrations

### Objective

This module will enable you to describe first-order RWD driveline vibrations.

### Identifying the Source

Once a disturbance has been identified as driveline related, continue testing in your service area.

### Sources of First-Order Driveline Vibrations

- Propeller shafts
- Pinion flange
- Transmission/transfer case output shaft
- Pinion gear

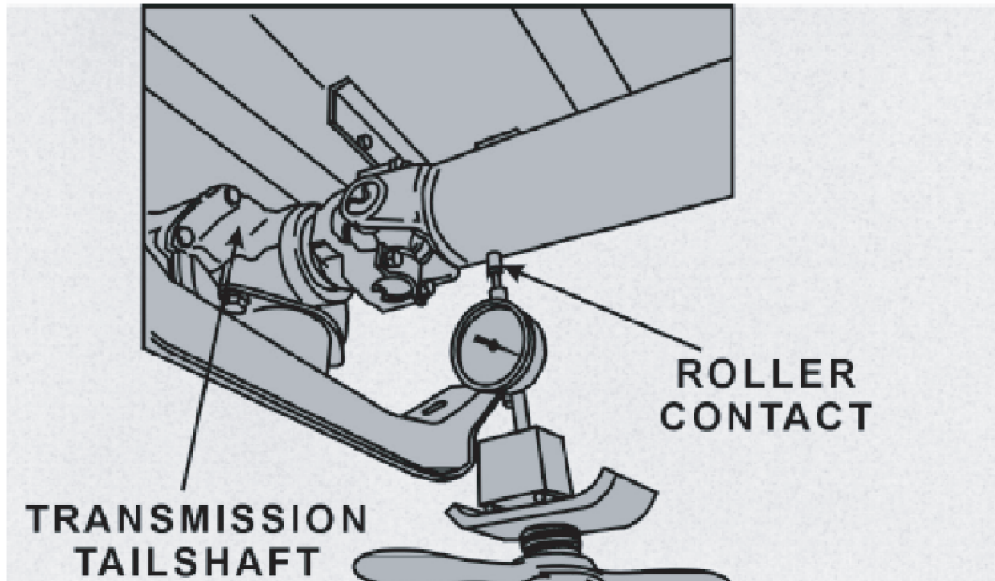
To pinpoint the source, you must reproduce the vibration in the service stall; and then determine which component is vibrating the most using the EVA.

- Support vehicle on a suitable hoist or jack stands with rear axle at curb height. On AWD and 4WD vehicles, make sure both axles are supported
- Remove rear tire/wheel assemblies and brake drums. On vehicles with disc brakes, it is necessary to reinstall wheel nuts to hold brake rotor against spindle flange

#### **Warning:**

**Do not apply the brakes while the drums are removed.**

- Make sure propshaft is free of undercoating, and check for dents or damage to propshaft or U-joints
- Start engine, place transmission in gear, and run vehicle at speed which vibration occurs



*Figure 5-54, Measuring Propshaft Runout*

First-order driveline vibrations can be caused by excessive runout of the propshaft, or of the pinion (companion) flange.

- If vehicle has a two-piece propshaft, you must also check center support bearing
- If transmission tail shaft is vibrating, check transmission cross member under transmission mount.
  - Vibration should not be present if mount is doing its job

**Notice:**

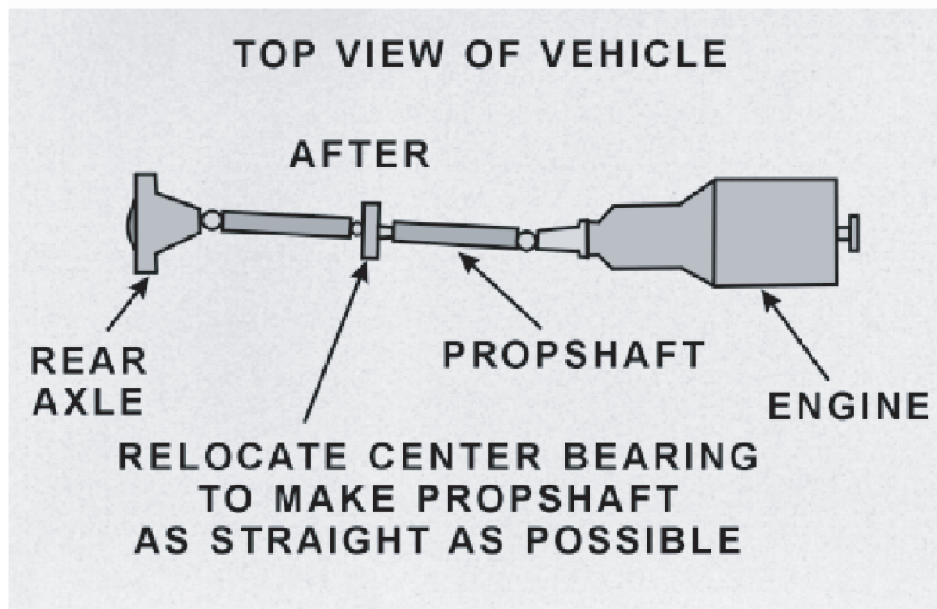
Never fill the propshaft with foam, oil, or any other substance in an attempt to correct a vibration.

This procedure:

- Is only effective in reducing an unrelated condition called "torsional rattle"
- Should only be performed in strict adherence to the procedure outlined in corporate bulletins that address this concern

**Caution**

**Failure to follow the correct procedure will induce a vibration and/or affect the structural integrity of the propshaft. Replacement would then be necessary.**



*Figure 5-55, Center Support Bearing*

First-order driveline vibrations that are felt mainly at the center support bearing are usually the result of excessive runout at the stub (splined) shaft.

- Vibrations can appear at unusually low speeds of 25 mph and up
  - Because soft rubber cushion, part of center support bearing, has responses that can be excited by low frequencies

**ASE 4 - Suspension and Steering****Module 5 - Vibration Correction****To correct this type of vibration:**

- Mark position of rear propshaft at both ends for proper reassembly
- Remove it from vehicle. Measure runout of splines about 1/2-inch from the end
- If runout exceeds tolerances, shaft must be replaced with a shaft with acceptable runout (the less, the better), or straightened and rebalanced by a reputable independent

Correcting the stub shaft/spline runout will usually eliminate the vibration. If some residual vibration is still present, perform a road test on the vehicle and determine if an on-vehicle system balance of the driveline is necessary.

First-order driveline vibrations that originate at the transmission end of the propshaft are rare.

If the vibration cannot be felt at the cross member, then the transmission mount is doing its job of isolating the vibration from the structure of the vehicle. It is most likely not the source of the customer concern.

- If tail shaft of transmission is vibrating, check tailshaft housing bushing to make sure it is not worn or damaged
- A leaking transmission tailshaft oil seal is also an indication of bushing concerns

If the vibration can be felt on the cross member, and the tailshaft bushing and transmission output shaft appear normal:

- Check for excessive runout:
  - Replace shaft with one that has acceptable runout (the less, the better)
- Sublet shaft to a reputable independent to have runout corrected and shaft rebalanced
- Evaluate vehicle on a test drive.
  - If vibration is still at an unacceptable level, shaft may need to be system balanced
- Run engine at vibration speed with propshaft removed.
  - If a first-order vibration is still present, vibration is due to an internal transmission or transfer case component

## Pinion Flange Runout

Whenever excessive prop shaft runout is identified, pinion flange runout should be measured. You'll need a pinion flange runout gauge (J-35819), dial indicator extension (J-23409), and dial indicator set (J-8001) or equivalent tools to perform this procedure.

### Notice:

- Readings are going to be inverted
- Measure the inside diameter of the flange, and not the outside diameter
- The highest reading on dial indicator is the low spot
- The lowest reading will be the high spot

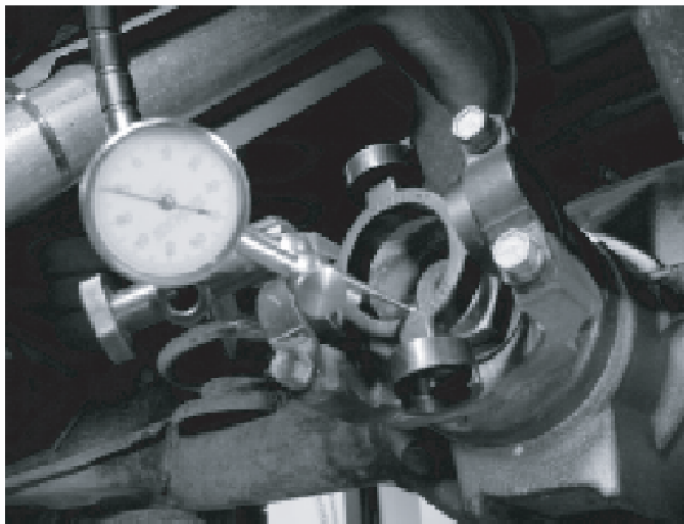


Figure 5-56,

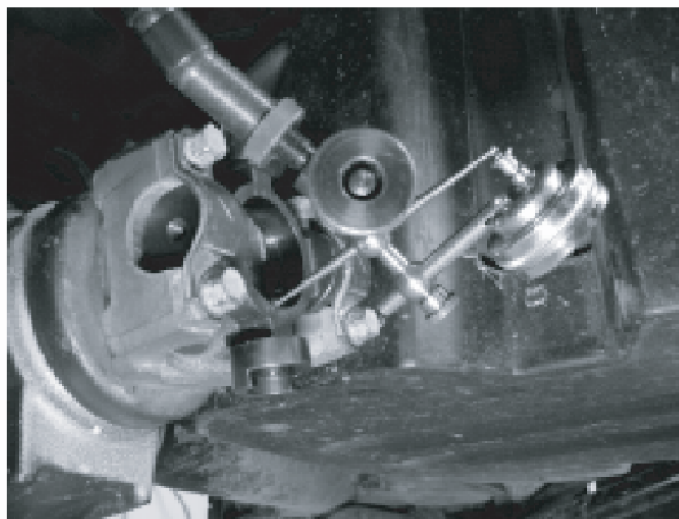


Figure 5-57,



## Pinion Flange Runout Compensation Weight

If used, it will be located on the face of the pinion flange dust slinger.

- It is tack-welded onto the slinger and can be removed with a die-grinder
- Carefully remove spot weld at either end of weight
- Do not remove weight, unless you have checked pinion flange runout and service manual procedure calls for removal

### Caution

**Do not remove any weights that may be present on outboard edge of dust slinger. These weights are installed to balance internal axle components, and are not related to pinion flange runout**

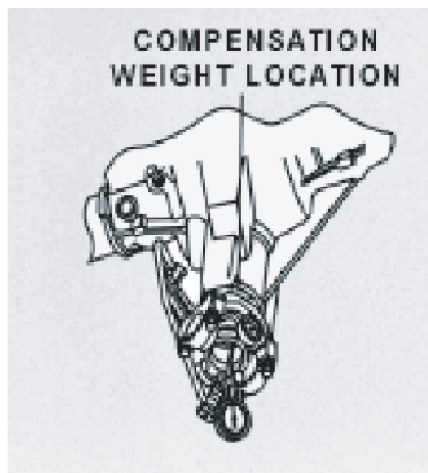


Figure 5-58,

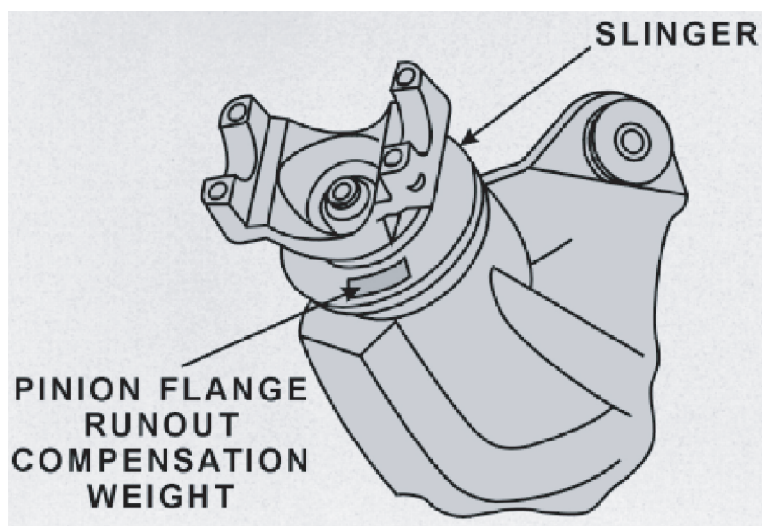


Figure 5-59,

## Specifications:

- If runout is 0.006-inch (0.15mm) or less, there shouldn't be a weight. If there is, remove pinion flange balance weight
- If runout is 0.006-inch (0.15mm) - 0.011-inch (0.28mm) and compensation weight is at or near the low spot, no further action is required.
- If runout compensation weight is not at or near the low spot, remove weight.
- If runout is 0.011 -inch (0.28mm) - 0.015-inch (0.38mm), and balance weight is at or near the low point, no further action is required.
- If runout compensation weight is not at or near the low spot, remove weight and re-index pinion flange until runout is 0.010-inch (0.25mm) or less.

## Notice:

If it's impossible to achieve 0.010-inch (0.25mm) runout or less, replace the pinion flange according to directions in Service Information. Then recheck the runout to see if it's in tolerance. Service replacement flanges do not have balance weights.

The pinion nose end of the drive shaft is usually where first-order driveline vibrations originate.

- Due to resonances within the structure of rear axle assemblies, they can be very sensitive to these conditions
- Vibration at this location must be reduced to a minimum to achieve acceptable results
- Reduce runout of components to a minimum
- System balance driveline if necessary



On axles using a "crush" type sleeve to achieve pinion bearing preload, the pinion flange may only be removed and reinstalled one time. Otherwise, you will need to replace the crush sleeve subsequent times. After the sleeve has been "crushed," it must be replaced with a new sleeve.

### **Replace A Sleeve**

- This requires removal of ring and pinion gear set
- For this reason, it is probably a good idea to replace flanges with excessive runout rather than chancing the re-indexing method
- Regardless of the method used, pinion flange runout should be measured afterward to ensure it is within tolerance

### **Strobe Balancing**

If the runout measurements are within tolerance, the driveline should be strobe balanced. The EVA can simplify this process.

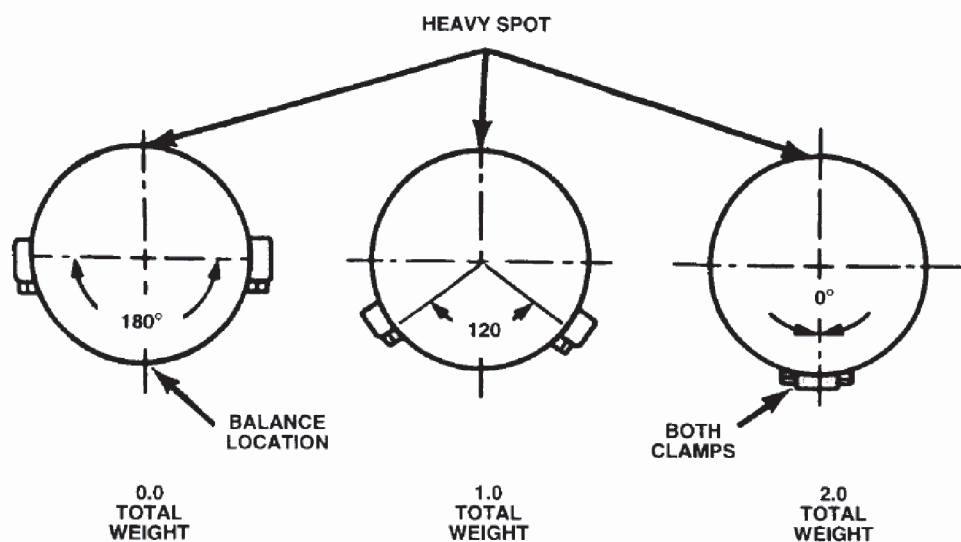
- Mark and number propshaft at four points
- Set up EVA for strobe balance
- Start engine turn off accessories
- Point timing light at propshaft
- Note which point in relation to the numbered marks is at the bottom of the propshaft
- Turn off engine and install weight on light spot
- Start engine, run at correct speed and strobe again

If balance has not been achieved, one of three situations will occur when you strobe after adding weight:

- Strobe flash in same position
- Need more weight
- Add a second weight next to the first
- Re-strobe and adjust the weights as needed
- Weight (and original light spot) is 90 to 180 degrees off, between 9 and 3 o'clock positions
- Weight (and original light spot) is within 180 degrees of 6 o'clock position

**ASE 4 - Suspension and Steering****Module 5 - Vibration Correction**

- When the weight (and original light spot) is 90 to 180 degrees off, between 9 and 3 o'clock positions, one weight was too much
- Split two weights equally on either side of original light spot to produce a total weight less than one (between 120 and 180 degrees apart)
- Re-strobe and adjust weights as needed
- If the weight (and original light spot) is within 180 degrees of 6 o'clock position
  - Change location of weight towards 6 o'clock position
  - Re-strobe until balance is achieved or one of the above conditions occurs
- If more than two weights are needed, place a third on the light spot.
- Split first two weights to produce total weights between two and three
- If three weights fail to balance driveline, propshaft should be replaced
- Once driveline is balanced, road test vehicle again to verify that vibration has been eliminated

*Figure 5-60,*

## Torque Sensitive Driveline Vibrations

If the vehicle has a vibration that is equal to first-order driveline rotation, and it is not present when testing the vehicle in the stall, then it is possible that the vibration is being generated by internal rear axle components.

- This may also be true if vibration was correctable in stall, but returned when vehicle was driven on the road
- These vibrations tend to be aggravated by load of vehicle working against ring and pinion gear set
- The vibrations it produces will have same frequency and symptoms, since pinion gear operates at exact same speed as propshaft

### Notice:

If the pinion nose vibrates under acceleration/deceleration, and the other driveline components have been eliminated as a cause, then the concern may exist within the rear axle.

Anything that can affect the pinion gear and how it contacts the ring gear as it rotates could contribute to a first-order, torque sensitive driveline vibration.

The only way to correct these conditions is to replace the affected components.

- Ring and pinion gear set and related bearings
- Axle housing

There is no way to effectively measure or identify exact component at fault, except close visual inspection for unusual wear marks that may or may not be present.

Sometimes the installation of a "known good" axle assembly from a stock unit is the best way to quickly isolate the cause of an axle vibration.

- Always qualify or evaluate the "known good" stock unit to ensure that it does not have a vibration itself
- Once an internal axle vibration has been corrected, perform a road test to determine if the vibration has been eliminated.

## Lesson 7: Second-Order RWD Driveline Vibrations

### Objective

This module will enable you to describe second-order RWD driveline vibrations.

### Second-Order Vibrations

- Due to the operational characteristics of U-joints, a vibration that occurs twice per revolution of the propshaft may occur
- As previously mentioned, a vibration that occurs twice per revolution of a component is termed second-order
- As the propshaft rotates, the U-joints actually speed up and slow down, twice for every revolution of the propshaft
- The acceleration and deceleration of the U-joints cannot always be seen, but may be felt or heard
- The greater the angle, the more pronounced the effect

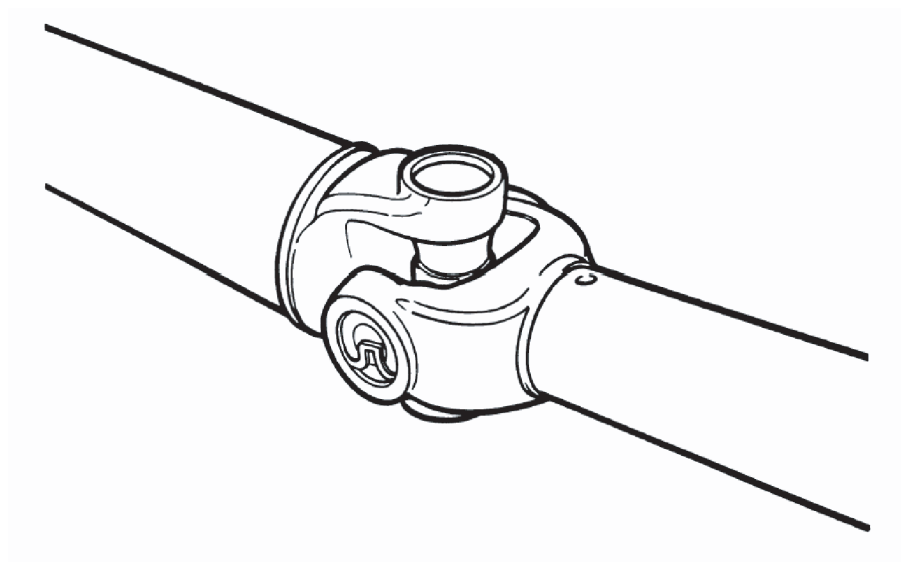


Figure 5-61, U-Joints

## Working Angles

Proper Working Angles:

- The U-joints are parallel and in phase when the front joint and rear joint is horizontal to one another
- Working angles at each joint are equal
- If the speed of the sprocket is constant (mock-up)
- The center sprocket is an irregular rate due to the acceleration and decelerations of the first U-joint
- The rear or outer sprocket is rotating smoothly because of correct working angles and parallel phase

Improper Working Angles:

- The ability to cancel out the accelerations of the first u-joint with the decelerations of the second U-joint no longer exist

## Driveline Working Angles

If a second-order driveline vibration exists after these conditions have been corrected, driveline angles should be measured and corrected.

If concern is present only with cargo in vehicle, it may be necessary to perform measurements with vehicle fully loaded

Keep in mind that once a second-order driveline vibration has been corrected with vehicle loaded, it may reappear with vehicle unloaded and vice versa

You may need to reach a compromise with customer in these cases

Driveline working angle does not refer to the angle of any one shaft, but to the angle that is formed by the intersection of two shafts.

The procedure for measuring and correcting driveline working angles depends on whether the vehicle is equipped with a one-, two-, or three-piece propshaft.

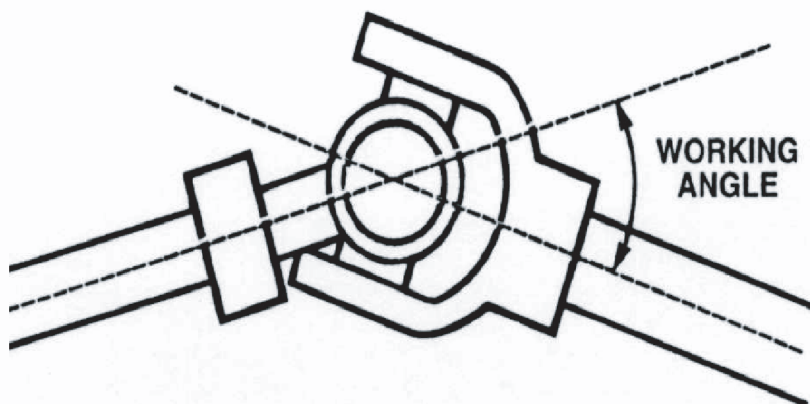


Figure 5-62, Working Angle

Inclinometer J-23498, digital inclinometer J-38460, or an equivalent tool will be necessary to perform these measurements.

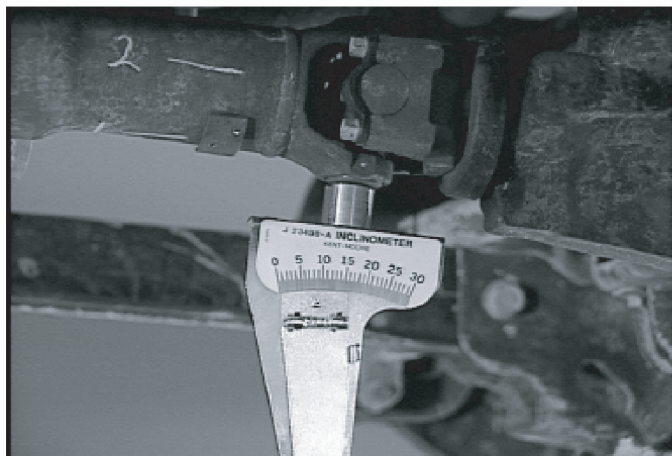


Figure 5-63, Inclinometer

- Bubble inclinometer J-23498-A has a magnetic base for mounting on joint bearing caps, along with a bubble level and angle scale for taking accurate measurements
- Digital inclinometer display eliminates guesswork and is accurate to 1/10th of a degree
- Use adapter J-23498-20 for joints that are inaccessible

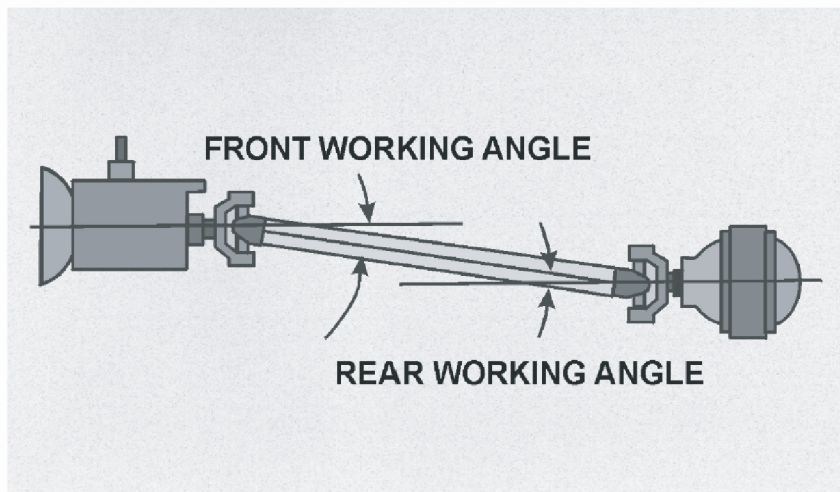


Figure 5-64,

In a one-piece propshaft system there are two working angles present, the front and the rear.

For proper cancellation to take place, please follow these guidelines:

- Front working angle formed by propshaft and transmission tailshaft should be equal
- Rear-working angle formed by propshaft and rear axle pinion



The angles of these components are most accurately measured from the U-joint bearing caps.

- Bearing caps should be free of corrosion or foreign material to ensure accurate readings
- Remove any snap rings that may interfere with correct placement of inclinometer, but be sure to reinstall them after measurements have been taken
- For consistent results, read tool from same side of vehicle throughout testing

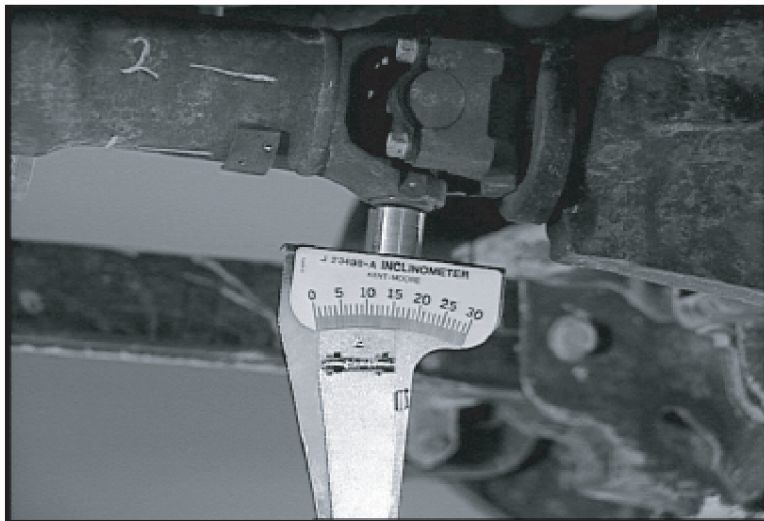


Figure 5-65,



Figure 5-66,

**ASE 4 - Suspension and Steering****Module 5 - Vibration Correction****Rules Of Thumb For Angle Results**

- The two working angles should be equal within  $\frac{1}{2}$  of a degree
- Working angles should not exceed 4 degrees
- Working angle should not be equal to zero

If the working angle is zero:

- Needle bearings within a U-joint will not rotate
- Premature wear of U-joint will result
- Working angle of the "odd" joint for a two-piece propshaft is to be kept at or below  $\frac{1}{2}$  degree, but not zero
- Keep working angle of this "odd" joint to a minimum so that there are not any great fluctuations in speed that need to be cancelled out

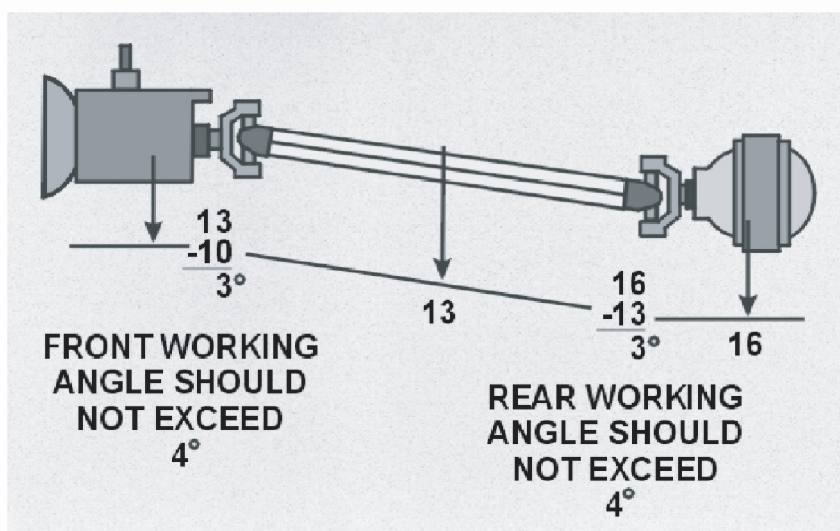


Figure 5-67, Calculating Working Angles

The working angles in this example allow effective cancellation to take place.

- Both angles are the same
- Effective cancellation would take place, because the difference is  $\frac{1}{2}$  degree or less and the working angles are less than 4 degrees themselves



## U-Joint Phasing

- U-joints that are out of phase occur when one U-joint is vertical and the other U-joint is horizontal
- Working angles are still equal; the only change is the U-joints are out of phase
- By re-phasing the front and rear U-joints are horizontal and the driveline is considered in-phase

The lateral alignment should also be checked (and adjusted if necessary), before measuring and adjusting driveline angles.

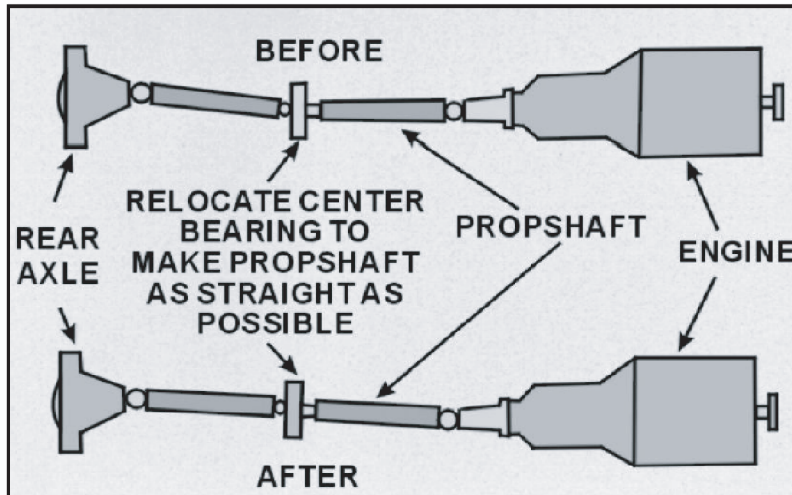


Figure 5-68,

## Proper Propshaft Working Angles

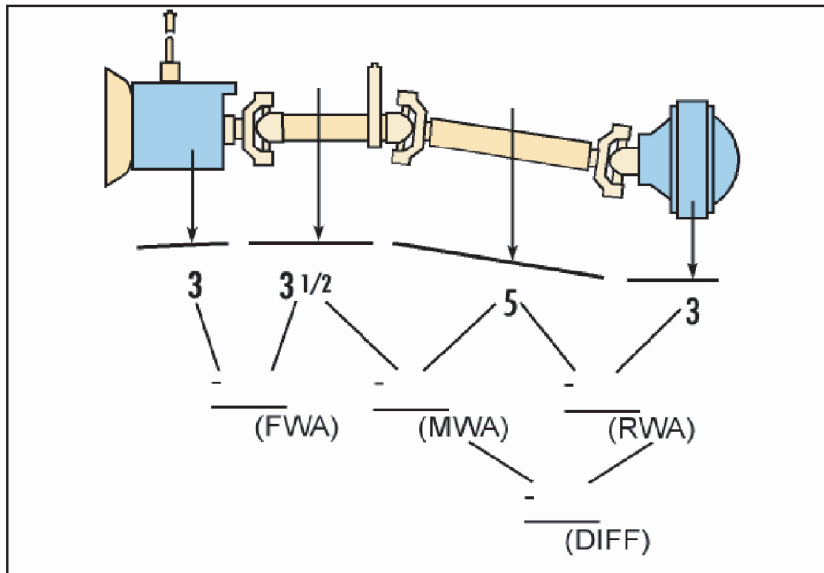


Figure 5-69,

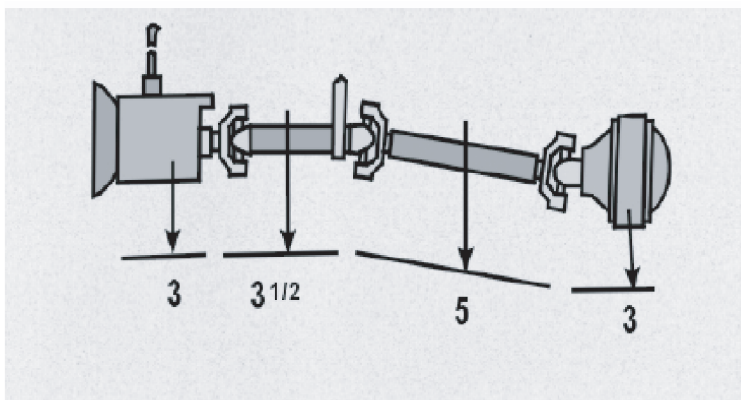


Figure 5-70,

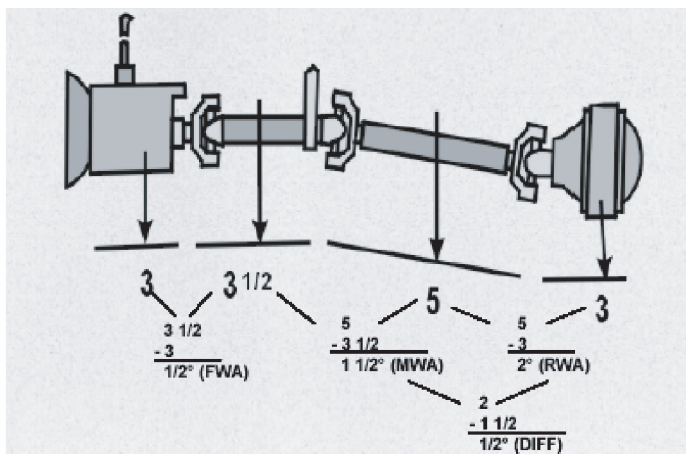


Figure 5-71,

## Student Workbook

### ASE 4 - Suspension and Steering

### Module 5 - Vibration Correction



- Front working angle is  $\frac{1}{2}$  degree
- Middle working angle is  $1\frac{1}{2}$  degrees
- Rear working angle is 2 degrees
  - The difference is  $\frac{1}{2}$  degree
- For proper phasing, the U-joints at each end of the propshaft should be within 3 degrees of each other
- The angle of the first or odd joint in a two-piece system should be between 0.10 and 0.50 degrees
- For proper cancellation, the 2nd and 3rd working angles should be within 0.50 degrees of each other
- No U-joint angle in a two-piece system should exceed 4 degrees

#### **Caution**

**Never shim a rear axle equipped with composite leaf springs. Shimming such an axle may result in damaging or breaking composite leaf springs**

## Lesson 8: Engine-Related Vibrations

### Objective

This module will enable you to describe engine-related vibration.

### Engine Related Vibration

Any disturbance or vibration identified during the following tests are considered engine-related:

- Neutral Run-Up Test
- Downshift Test
- Brake Torque Test

### Firing Frequency

Firing frequency is a term used to describe the pulses that an engine creates as it fires each cylinder

### Symptoms Of Firing Frequency

- The vibration may be torque sensitive
- It's always engine-RPM related
- Usually it's heard as an audible boom or moan

Many times the vibration excites the resonance of a system or component, causing it to have a narrow RPM range.

The key to correcting these types of concerns is to isolate the vibration from the passenger compartment or body.

The frequency of these disturbances will depend on how many cylinders the engine has.

### Isolating Vibrations

Duplicate vibration while vehicle is on an inspection-type hoist (either a front-end rack or similar hoist that supports vehicle at curb height)

- While vibration is present, find area(s) of vehicle that are excited or responding to vibration
- Look closely for witness marks due to a rubbing component
- Once an area of vehicle has been pinpointed, component should be isolated and vibration reevaluated

## Inherent Shaking Forces

Some residual vibrations may be normal. Compare them with a similar vehicle to get a feel for what is commercially acceptable. Then, demonstrate it to the customer.

Also refer to bulletins pertaining to the use of mass damper weights for specific

applications (GM P/N #488674). Just like firing frequency, some engine disturbances are the result of normal operation.

Due to the cylinder arrangement, design, and firing order, some of today's engines can have additional inherent vibrations.

|       |                        |      | Firing Frequency              |                               |                               |
|-------|------------------------|------|-------------------------------|-------------------------------|-------------------------------|
|       | First Order Any Engine |      | 4-Cylinder<br>Second<br>Order | 6-Cylinder<br>Second<br>Order | 8-Cylinder<br>Second<br>Order |
|       | RPM                    | Hz   |                               |                               |                               |
| Shake | 500                    | 8.3  | 16.6                          | 24.9                          | 33.2                          |
|       | 750                    | 12.5 | 25                            | 37.5                          | 50                            |
|       | 1000                   | 16.6 | 33.3                          | 49.8                          | 66.4                          |
|       | 1500                   | 25   | 50                            | 75                            | 100                           |

Figure 5-72, Engine Order Vibration Chart

Component speed for engine-speed-related concerns can be calculated by dividing engine RPM by 60

Divide the first column RPM by 60 which gives the frequency in Hertz (Hz)

Engine-driven accessories that exhibit vibration pose a special challenge.

With the advent of serpentine belts, you can no longer remove the belts one at a time to

isolate the condition. Many times the most effective repair is isolating the disturbance (as with firing frequency or other inherent vibrations), rather than attempting to eliminate the source. Compare these vibrations to a known good vehicle to make sure they are not normal.

## Smart Strobe

- Smart Strobe mode enables complete control of the frequency at which the strobe light will flash
- Mark the pulley, trigger the strobe at maximum vibration and adjust the frequency until the mark is stationary
- If the pulley vibration frequency matches the frequency received during Auto Mode testing, we've found the out of balance object
- Clip the inductive pickup of the timing light to the "loop" on the EVA 2, and connect to a 12-volt power source
- From the Main menu, select Smart Strobe
- Mark the object you suspect is causing vibration
- Enter an initial test point strobe frequency between 10-200 Hz (600-1200 RPM). Then press the "0" key to toggle to an RPM display
- Press the strobe light trigger as you point the strobe light at the spinning object, then press the EVA 2  $\overline{\text{+}}$  or - keys to manually adjust the RPM until only one mark is seen and the mark appears stationary.
- As the test is run, the strobe speed must be manually adjusted to match the actual object RPM.

## Accessories

Once you have isolated the pulley that is causing the vibration, you should also check for conditions, such as:

- Pulley misalignment or bent pulleys, which may also be a factor in accessory vibration
- Air conditioning systems, which are susceptible to overcharging or excessive oil that may result in abnormal operating characteristics

## Summary

Review:

- Vibrate software
- RWD Driveline vibrations
- Strobe balancing
- Driveline working angles
- Engine-related vibrations

## Exercise 5-1

Read each question carefully and choose the correct response.

1. Which of the following is the next step after a vibration is duplicated and thought to be abnormal?
  - a. Identify the frequency of the vibration
  - b. Match the vibration's frequency to component
  - c. Calculate propshaft rotation
  - d. Determine tire runout
  
2. Which of the following statements is NOT true about correcting vibrations?
  - a. All vibrations can be corrected on a vehicle
  - b. The vibration must be duplicated before attempting repair
  - c. The vibration must be isolated before attempting repair
  - d. Components should be visually inspected before attempting repair
  
3. Which of the following is NOT a step to correct launch shudder concerns in front-wheel drive vehicles?
  - a. Check torque convertor clutch operation
  - b. Measure trim or spring height
  - c. Add sandbags until disturbance is eliminated
  - d. Road test
  
4. Which of the following diagnostic processes involves gathering and deciphering information and then performing a correction based on the results?
  - a. Road testing
  - b. Performing published diagnostic tests
  - c. Strategy Based Diagnostics (SBD)
  - d. Performing unpublished diagnostic tests

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5. All of the following are included in preliminary checks performed during troubleshooting EXCEPT \_\_\_\_\_.
  - a. Visual inspection
  - b. Check the vehicle's history file
  - c. Check bulletins
  - d. Operational check
  
6. To determine the cause and best repair method of a vibration or noise, one of the first things technician should do is \_\_\_\_\_.
  - a. Duplicate the vibration or noise
  - b. Check for DTCs
  - c. Check tire pressure
  - d. Check service information
  
7. Which of the following is the first step of Strategy Based Diagnostics?
  - a. Make quick checks
  - b. Verify customer concern
  - c. Check for service bulletins
  - d. Perform diagnostic system checks
  
8. After identifying a first order driveline vibration, the next step is to \_\_\_\_\_.
  - a. Measure working angles
  - b. System balance driveline
  - c. Measure propshaft runout
  - d. Measure companion flange runout
  
9. To duplicate a customers concern, the technician needs to know all of the following EXCEPT \_\_\_\_\_.
  - a. Any noise the vibration generates
  - b. Where the vibration is felt
  - c. The speed at which the vibration is most noticeable
  - d. The vehicle's regular production option codes





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10. During a downshift test, if the vibration returns at the same engine RPM, the most probable cause will be the \_\_\_\_\_.
- Transmission input shaft
  - Transmission output shaft
  - Torque converter
  - Slip yoke
11. A customer has a concern of a boom type noise while at highway speeds. Which of the following diagnostic tests should be performed?
- Brake torque test
  - Steering input test
  - Neutral coast down test
  - Standing start acceleration test
12. Technician A states the brake torque test is used to identify transmission related vibration problems. Technician B states that the brake torque test is used after engine speed related vibrations were NOT uncovered by the neutral run up test. Which technician is correct?
- Technician A
  - Technician B
  - Both technicians are correct
  - Neither technician is correct
13. All of the following are types of road tests, EXCEPT \_\_\_\_\_.
- Slow acceleration test
  - Neutral coast down test
  - Down shift test
  - Engine run down test
14. Which of the following tests would be used for a vibration concern that occurs at idle?
- Brake torque test
  - Neutral coast down test
  - Neutral run up test
  - Slow acceleration test



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15. A slow acceleration test is used to identify \_\_\_\_\_.
  - a. Engine speed related conditions only
  - b. Vehicle speed related conditions only
  - c. Both vehicle and engine speed related conditions
  - d. Launch shudder concerns only
  
16. Which of the following noises sometimes causes customers to complain of pressure in their ears?
  - a. Howl
  - b. Boom
  - c. Moan
  - d. Whine
  
17. Which of the following noises is somewhat higher than a boom and can also be described as humming?
  - a. Howl
  - b. Whine
  - c. Buzz
  - d. Moan/drone
  
18. Which of the following noises has the highest frequency?
  - a. Whine
  - b. Moan
  - c. Howl
  - d. Boom
  
19. Which of the following noises has the lowest frequency?
  - a. Boom
  - b. Howl
  - c. Moan
  - d. Whine



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20. A moan or drone is usually related to the \_\_\_\_\_.
- Exhaust system
  - Driveline components
  - Meshing of gears
  - Tires/wheels
21. A boom is usually related to \_\_\_\_\_.
- Driveline components
  - Vehicle alignment
  - Gears
  - Exhaust system elements
22. Which of the following vibration noises would most likely be caused by an air conditioner compressor?
- Buzz
  - Boom
  - Roughness
  - Tingling
23. Which of the following vibration noises would be related to driveline components?
- Boom
  - Moan
  - Howl
  - Whine
24. At which frequency is a moan or drone typically heard?
- 20 to 60 Hz
  - 60 to 120 Hz
  - 120 to 300 Hz
  - 300 to 500 Hz

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25. If a component is vibrating at 20 cycles per second, what is its vibration frequency?
- 20 Hz
  - 20 cpm
  - 1200 Hz
  - 1200 cpm
26. Frequency can be expressed in all of the following ways EXCEPT \_\_\_\_\_.
- Cycles per second
  - Cycles per minute
  - Amplitude
  - Hz
27. The point where a vehicle vibrates the most is called the \_\_\_\_\_.
- Point of resonance
  - Transponder
  - Cycle
  - Transfer path
28. Which of the following are the most common causes of vehicle vibration concerns?
- Springs, struts and shocks
  - Wheels, springs and shocks
  - Wheels, tires, hubs, drums, and rotors
  - Tires, springs and struts
29. If a component is vibrating at 13 cycles per second (Hz), what is its vibration frequency in cycles per minute (cpm)?
- 1080
  - 780
  - 130
  - 48



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30. Which of the following is the route that the vibration takes through a vehicle?
- a. Transfer path
  - b. Source
  - c. Transmission
  - d. Responder
31. Which of the following is NOT one of the three component groups that most commonly produce vibrations?
- a. Steering column and linkage
  - b. Transmission output shaft, propshaft, and the pinion flange
  - c. Engine and torque converter
  - d. Wheels, tires, hubs, drums, and rotors
32. The ability of an object or material to dissipate or absorb vibration is called \_\_\_\_\_.
- a. Beating
  - b. Phasing
  - c. Damping
  - d. Resonating
33. The specific amount of force produced by a vibrating component is measured in \_\_\_\_\_.
- a. Frequency
  - b. Amplitude
  - c. CPM
  - d. Hz
34. The frequency of a vibration will \_\_\_\_\_ as the speed of a vibrating component \_\_\_\_\_.
- a. Increase; increases
  - b. Decrease; increases
  - c. Increase; decreases
  - d. Decease; decreases



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35. Excessive runout of the driveline or imbalance of the driveline components can cause \_\_\_\_\_.
- First-order driveline vibration
  - Second-order driveline vibration
  - Third-order driveline vibration
  - Engine speed vibration while in overdrive
36. Which of the following is a symptom of a first-order driveline vibration?
- It is always related to engine speed
  - It occurs at speeds between 5-15 mph
  - It occurs once per propshaft revolution
  - Noise is never present
37. Which first-order tire vibration is most common?
- Excessive static runout
  - Excessive imbalance
  - Excessive lateral runout
  - Excessive lateral force variation
38. Which of the following is NOT a symptom of first-order driveline vibrations?
- The vibration is dependent on engine-speed
  - The vibration may be torque sensitive
  - The vibration may occur at speeds as low as 30 mph
  - Noise may be present
39. The order of a vibration refers to \_\_\_\_\_.
- the magnitude of the disturbance
  - the transfer path of the vibration
  - how many times the event happens in one complete revolution
  - the speed you feel the vibrations



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40. First-order vibrations caused by wheel/tire assemblies are always \_\_\_\_\_.
- a. Vehicle-speed related
  - b. High frequencies
  - c. Engine speed related
  - d. Felt under a load
41. Which of the following components is least likely to produce a first order wheel and tire vibration on a front wheel drive vehicle?
- a. Tire
  - b. Brake rotor
  - c. Wheel
  - d. Tripod joint
42. On a front wheel drive vehicle, first order drive axle vibrations will \_\_\_\_\_.
- a. Be at the same frequency as wheel and tire group
  - b. Only occur at speeds over 50 mph.
  - c. Be dependent on engine RPM
  - d. Depend on the planetary gear set ratio
43. Technician A states that a first order vibration will NOT produce a sound. Technician B states that a first order vibration can produce a sound at certain speeds. Which technician is correct?
- a. Technician A
  - b. Technician B
  - c. Both technicians are correct
  - d. Neither technician is correct
44. Vibrations produced by the pinion gear will have \_\_\_\_\_ frequency and symptoms as one produced by an out of balance propshaft.
- a. The same
  - b. Twice the
  - c. Higher
  - d. Lower



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45. Which of the following is the most common concern of second-order driveline vibration?
- Launch shudder
  - Excessive runout
  - Lateral force variation
  - Incorrect tire/wheel balance
46. Which of the following is the most common cause of second-order driveline vibrations?
- Incorrect driveline working angles
  - Lateral force variation
  - Out of balance propshaft
  - Excessive ring and pinion backlash
47. How many disturbances per propshaft revolution will be caused by worn universal joints?
- One
  - Two
  - Three
  - Four
48. Which of the following is NOT a symptom of second order driveline vibrations?
- Vehicle speed related
  - Torque sensitive
  - Launch shudder
  - Boom noise
49. A second-order driveline vibration can be caused by \_\_\_\_\_.
- Two first-order vibrations
  - Improper working angles
  - Second-order engine vibration
  - Excessive runout of the driveline





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50. Technician A states that second-order driveline vibrations can be caused by worn U-joints. Technician B states that second-order driveline vibrations can be caused by incorrect working angles. Which technician is correct?
- a. Technician A
  - b. Technician B
  - c. Both technicians are correct
  - d. Neither technician is correct
51. Improper U-joint cancellation may cause \_\_\_\_\_.
- a. Second-order propshaft vibrations
  - b. Vibration on deceleration only
  - c. Second-order tire/wheel vibrations
  - d. Second-order engine vibration
52. How many vibrations per single revolution of the axle shaft will be caused by worn or damaged inner tri-pod joints?
- a. Three
  - b. Two
  - c. One
  - d. Four
53. In some applications, 3rd order wheel and tire vibrations could be at or near the same frequency as \_\_\_\_\_.
- a. 1st order driveline
  - b. 2nd order driveline
  - c. 3rd order driveline
  - d. 1st order engine vibration in overdrive
54. Besides launch shudder, which of the following concerns will a worn tri-pod joint cause?
- a. Whine noise
  - b. Brake chatter
  - c. Vehicle speed related first order tire vibrations
  - d. Vehicle speed related third order tire vibrations

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55. Which of the following is the probable cause of launch shudder in front-wheel-drive vehicles?
- a. Damaged inner tri-pod joints
  - b. Imbalanced torque converter
  - c. Imbalanced tire/wheel assembly
  - d. Improperly installed U-joints
56. All of the following component responders may vibrate continuously as a result of a forced vibration EXCEPT \_\_\_\_\_.
- a. Steering wheel
  - b. Seat cushion
  - c. Instrument panel
  - d. Tire and wheel assembly
57. A spindle moving as a result of an imbalanced tire is an example of \_\_\_\_\_.
- a. A forced vibration
  - b. Damping
  - c. Resonance
  - d. A free vibration
58. First-order tire/wheel vibrations felt in the steering wheel are most likely related to the \_\_\_\_\_ tire/wheel assemblies.
- a. Front
  - b. Rear
  - c. Both front and rear
  - d. Driven
59. Which of the following should be corrected first when diagnosing a tire/wheel concern?
- a. Force variation
  - b. Match mounting
  - c. Runout
  - d. Static balance



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60. The tendency of a vehicle to be deflected sideways due to a ``snakey`` belt inside the tire is known as \_\_\_\_\_.  
a. Lateral force variation  
b. Wheel hub flange runout  
c. Wheel stud runout  
d. Radial force variation
61. A static tire balance problem will cause \_\_\_\_\_.  
a. The tire to shimmy  
b. The tire to bounce  
c. Steering pull  
d. Brake pull
62. Which of the following conditions is caused by lateral force variation?  
a. Wobble at low speeds  
b. Growling noise  
c. Roughness  
d. Shudder during turns
63. Technician A states radial force variation is the difference in stiffness of a tire as it rotates and contacts the road. Technician B states a first order vibration can be caused by one stiff spot on the tire. Which technician is correct?  
a. Technician A  
b. Technician B  
c. Both technicians are correct  
d. Neither technician is correct
64. Technician A states that stiff spots on the tire can cause a bent rim. Technician B states that stiff spots in the tire can deflect the tire and wheel assembly upward as the assembly contacts the road. Which technician is correct?  
a. Technician A  
b. Technician B  
c. Both technicians are correct  
d. Neither technician is correct

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65. Which of the following is the deflection of the tire/wheel assembly upwards as it contacts the road due to ``stiff spots`` in the sidewall of the tire?
- a. Radial force variation
  - b. Lateral force variation
  - c. Wheel hub runout
  - d. Wheel stud runout
66. Which of the following should NOT be performed if a concern still remains after correcting radial or lateral force variation?
- a. Inspect the front and rear alignment
  - b. Inspect the front and rear suspension
  - c. Perform a steering input test
  - d. Road test the vehicle to determine if the vibration is still present
67. If the pinion nose vibrates under acceleration/deceleration, the problem could be all of the following EXCEPT a \_\_\_\_\_.
- a. Worn u-joint
  - b. Mis-bored axle housing
  - c. Cocked pinion bearing
  - d. Damaged carrier bearing
68. Which of the following might cause a vibration in the rear axle?
- a. High spot on the pinion
  - b. Straight pinion stem
  - c. Improperly torqued wheel bearings
  - d. torque convertor clutch slip
69. Which of the following is a load sensitive vibration?
- a. Engine misfire
  - b. Tire/wheel imbalance
  - c. Propshaft imbalance
  - d. Engine imbalance



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70. Technician A states that the best way to diagnose a launch shudder is the brake torque test. Technician B states a launch shudder is a load-sensitive vibration. Which technician is correct?
- Technician A
  - Technician B
  - Both technicians are correct
  - Neither technician is correct
71. Technician A states that driveline vibrations are not vehicle-speed related. Technician B states that driveline vibrations are NOT torque sensitive. Which technician is correct?
- Technician A
  - Technician B
  - Both technicians are correct
  - Neither technician is correct
72. What could cause a launch shudder condition even though all working angles are within specifications?
- Driveline imbalance
  - Tire imbalance
  - Rear axle wind-up
  - Worn ring and pinion
73. A customer has a concern of a shudder only while accelerating from a stop sign. Technician A states this may be caused by a worn U-joint. Technician B states that this may be caused by weak rear springs. Which technician is correct?
- Technician A
  - Technician B
  - Both technicians are correct
  - Neither technician is correct

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74. Front-wheel-drive vehicles will NOT exhibit \_\_\_\_\_ vibration conditions.
- Engine
  - Propshaft
  - Tire/wheel
  - Launch shudder
75. While diagnosing a vibration on a front wheel drive vehicle, a technician notes a first-order tire/wheel vibration. All of the following should be inspected EXCEPT \_\_\_\_\_.
- Tire imbalance
  - Rotor imbalance
  - Stud runout
  - Inner tri-pod joint
76. When diagnosing a launch shudder on a front wheel drive vehicle, all of the following should be inspected EXCEPT \_\_\_\_\_.
- Universal joints
  - Inner tri-pod wear
  - Trim height
  - Worn engine/transaxle mounts
77. Technician A states that a launch shudder on a front wheel drive vehicle is felt under acceleration. Technician B states that a launch shudder on a front wheel drive vehicle will show up as a third-order vibration. Which technician is correct?
- Technician A
  - Technician B
  - Both technicians are correct
  - Neither technician is correct
78. On front-wheel drive equipped vehicles, a vibration during acceleration at 40 to 50 mph is usually caused by a/an \_\_\_\_\_.
- Inner c.v. Joint
  - Outer c.v. Joint
  - Wheel bearing
  - Worn lower ball joint

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79. Worn or damaged tri-pod joints can cause \_\_\_\_\_.
- a. Third-order tire-related vibrations
  - b. First-order tire-related vibrations
  - c. Second-order tire-related vibrations
  - d. Free vibrations
80. When diagnosing a front wheel drive vehicle, a bearing noise is heard on a right hand turn. Technician A states that the left front bearing may be the cause. Technician B states that during the right hand turn, more load is placed on the left wheel bearing. Which technician is correct?
- a. Technician A only
  - b. Technician B only
  - c. Both technicians are correct
  - d. Neither technician is correct
81. Technician A states that when diagnosing a vibration concern related to engine-driven accessories, the most effective diagnostic procedure may be to isolate the component. Technician B states that the most effective diagnostic procedure may be to perform a road test in direct drive. Which technician is correct?
- a. Technician A
  - b. Technician B
  - c. Both technician are correct
  - d. Neither technician is correct
82. Which of the following statements concerning engine related vibrations is NOT true?
- a. First order engine imbalance can cause a shake, roughness, or a buzz
  - b. Engine vibrations will always appear at the same engine speed
  - c. Engine firing order frequency will always be  $\frac{1}{2}$  of the number of the engine cylinders
  - d. Transmission gear placement can affect what RPM the engine vibration occurs



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83. Engine speed related vibrations are generally caused by any of the following conditions EXCEPT \_\_\_\_\_.
- a. First order engine imbalance
  - b. Inherent engine firing frequency
  - c. Inherent engine shaking forces
  - d. Imbalanced final drive
84. To convert engine speed in RPM to hertz, divide RPM by \_\_\_\_\_.
- a. 60
  - b. 120
  - c. 180
  - d. 6
85. During vehicle inspection, an engine vibration is noted. All of the following should be inspected EXCEPT \_\_\_\_\_.
- a. Powertrain mounts
  - b. Binding or groundouts in exhaust system
  - c. Condition of harmonic balancer
  - d. Ignition timing
86. Technician A states engine speed vibrations are always torque sensitive. Technician B states engine speed vibrations may appear and disappear at different vehicle road speeds. Which technician is correct?
- a. Technician A
  - b. Technician B
  - c. Both technicians are correct
  - d. Neither technician is correct
87. A first order engine imbalance can usually be detected during \_\_\_\_\_.
- a. Neutral run up tests
  - b. Slow acceleration tests
  - c. Neutral coast down tests
  - d. Downshift tests





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88. A customer has concern of a vibration at 25 mph, 40 mph, and 65 mph. The vibration may be caused by a/an \_\_\_\_\_.
- a. Imbalanced propshaft
  - b. Faulty transmission input shaft bearing
  - c. Imbalanced axle shaft
  - d. Engine related vibration
89. On a V8 engine, the EVA indicates a frequency of 80 Hz at 1200 RPM. Technician A states that 1200 RPM converts to 20 Hz; therefore, this is NOT an engine imbalance concern. Technician B states that the vibration is a result of engine firing pulses. Which technician is correct?
- a. Technician A
  - b. Technician B
  - c. Both technicians are correct
  - d. Neither technician is correct
90. Why will the engine order always be equal to one half the number of cylinders?
- a. Four stroke engines only fire half of the cylinders for every one revolution.
  - b. Four stroke engines only fire half of the cylinders for every two revolutions.
  - c. It is equal to less than half the number of cylinders
  - d. It is equal to more than half the number of cylinders
91. The frequency, in hertz, of a vibration that occurs at 3600 revolutions per minute is \_\_\_\_\_.
- a. 50
  - b. 60
  - c. 70
  - d. 80

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92. To check driveline working angles, which of the following tools is used?
- a. Dial indicator
  - b. Inclinator
  - c. Micrometer
  - d. Protractor
93. All of the following runout checks can be completed with a dial indicator EXCEPT \_\_\_\_\_.
- a. Rim runout
  - b. Pinion flange runout
  - b. Hub flange runout
  - c. Wheel bearing runout
94. All of the following items can be checked with a tire balancer EXCEPT \_\_\_\_\_.
- a. Tire and wheel assembly
  - b. Brake drum
  - c. Rotor
  - d. Hub assembly
95. Technician A states that when diagnosing a propshaft vibration with the EVA during a road test, the sensor should NOT be placed on the pinion nose because it may pick up road vibrations. Technician B states that when diagnosing a propshaft vibration with the EVA during a road test, the best location to place the sensor may be on the passenger side seat track. Which technician is correct?
- a. Technician A
  - b. Technician B
  - c. Both technicians are correct
  - d. Neither technician is correct

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96. All of the following statements are true about the EVA EXCEPT \_\_\_\_\_.
- a. It normally operates in an averaging mode to minimize the effect of sudden vibrations
  - b. In the non-averaging mode, it is more sensitive to vibration variations
  - c. It can be used to strobe balance a rotating component
  - d. It will only show one reading at a time
97. How is it determined which end of the propshaft is vibrating the most?
- a. By slow acceleration test
  - b. By using EVA to determine vibration amplitude at both ends of propshaft
  - c. By feel
  - d. By using a dial indicator
98. When testing with the EVA, the point at which the vibration is being induced will have \_\_\_\_\_.
- a. Greater amplitude
  - b. The same amplitude
  - c. Higher frequency
  - d. Lower frequency
99. Which of the following should be done to achieve consistent results when using the EVA?
- a. Up side of the sensor must be in up position every time
  - b. Use the same EVA for retests
  - c. Use a different EVA for retests
  - d. Compare to results from vibration worksheet
100. The sensor calibration on the EVA should be performed \_\_\_\_\_.
- a. Prior to every use
  - b. On new or additional sensors
  - c. After every use
  - d. Only at the factory



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101. Whenever the off-vehicle and on-vehicle lateral runout are significantly different, \_\_\_\_\_.
- a. Wheel stud runout check should be performed
  - b. Wheel hub flange runout should be performed
  - c. Balancers should be recalibrated
  - d. Inspect for a bent wheel rim
102. Where on the tire is radial runout tested?
- a. Outside edge of tire
  - b. Center of tire tread area
  - c. On the rim
  - d. Inside edge of tire
103. When checking a tire, the technician finds too much axial runout. Technician A says to rotate the wheel and tire on the drum to correct the concern. Technician B says to rotate the tire on the wheel to attempt to bring the runout within specs. Which technician is correct?
- a. Technician A
  - b. Technician B
  - c. Both technicians are correct
  - d. Neither technician is correct
104. Where on the tire is lateral runout tested?
- a. On the tire side wall as close to the tread as possible
  - b. Center of tire side wall
  - c. On the tire side wall as close to the rim as possible
  - d. Inside edge of tire
105. Match mounting tires is performed when \_\_\_\_\_.
- a. The tires cannot be balanced
  - b. Tire size is incorrect
  - c. Excessive runout is found
  - d. The tires are rotated



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106. Technician A states that it is possible that third and fourth order tire/wheel vibrations can occur as a result of radial force variation. Technician B states that third and fourth order tire vibrations can be mistaken as a first order propshaft vibration. Which technician is correct?
- a. Technician A
  - b. Technician B
  - c. Both technicians are correct
  - d. Neither technician is correct
107. Which of the following is a correct statement about the effects of a tire imbalance?
- a. Static imbalance will cause shimmy
  - b. Static imbalance will cause wheel hop
  - c. Dynamic imbalance will cause tire edge wear
  - d. Static imbalance will cause tire edge wear
108. Technician A states that vehicles are more sensitive to static imbalance than to dynamic imbalance. Technician B states that static imbalance affects the distribution of weight on each side of the tire/wheel centerline. Which technician is correct?
- a. Technician A
  - b. Technician B
  - c. Both technicians are correct
  - d. Neither technician is correct
109. Marking the drive shaft and yokes before disassembly is necessary to prevent \_\_\_\_\_.
- a. Difficult assembly
  - b. Lack of lubrication
  - c. Noise
  - d. Vibration

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110. In road testing a vehicle, it is found that the steering wheel shakes from side to side at higher speeds. Technician A states that this could be caused by front wheels NOT statically balanced. Technician B states that this could be caused by front wheels NOT dynamically balanced. Which technician is correct?
- a. Technician A
  - b. Technician B
  - c. Both technicians are correct
  - d. Neither technician is correct
111. Technician A states that before balancing a tire/wheel assembly, the tire/wheel should be inspected for debris or dirt build up. Technician B states that the tire and wheel runout should be checked before balancing. Which technician is correct?
- a. Technician A
  - b. Technician B
  - c. Both technicians are correct
  - d. Neither technician is correct
112. Dynamic imbalance results in \_\_\_\_\_.
- a. Side-to-side or shimmy motion
  - b. Wobble
  - c. Vertical or bouncing vibration
  - d. Launch shudder
113. For wheel and tire assembly vibrations, on-vehicle imbalance may be caused by all of the following EXCEPT \_\_\_\_\_.
- a. Hubs
  - b. Rotors
  - c. Drums
  - d. Tie rods

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114. Pinion flange runout can be measured by doing the following EXCEPT \_\_\_\_\_.
- Using a pinion flange runout gauge
  - Measuring high spot and low spot of the pinion flange
  - Checking propshaft runout as near as possible to the flange
  - Using a strobe light with a tech 2
115. Pinion flange runout should be checked when \_\_\_\_\_.
- Excessive propshaft runout indicates that shaft should be replaced
  - A second-order vibration is noted
  - Worn u-joints are detected
  - A third-order vibration under acceleration
116. Before attempting to system balance the driveline, \_\_\_\_\_.
- Check torque converter operation
  - Propshaft and pinion flange runout should be checked and corrected
  - Check tire and wheel balance
  - Check differential ring and pinion gear backlash
117. How many working angles should be checked in a one-piece propshaft?
- Four
  - Three
  - Two
  - One
118. Before measuring working angles on a one-piece propshaft, which of the following must be done if the propshaft is determined to be out-of-phase?
- Reweld the propshaft in the correct position
  - Replace the propshaft
  - Rotate the propshaft so the rear U-joint bearing cap is horizontal
  - Rotate the propshaft so the rear U-joint bearing cap is vertical



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119. Technician A states that a single piece propshaft must be replaced if the yokes are out of phase. Technician B states if a single piece propshaft is visibly out of phase, the shaft could be damaged due to twisting. Which technician is correct?
- a. Technician A
  - b. Technician B
  - c. Both technicians are correct
  - d. Neither technician is correct
120. Technician A states that four measurements need to be taken when determining working angle for a one-piece driveshaft. Technician B states that the center carrier bearing is not used in a one-piece driveshaft. Which technician is correct?
- a. Technician A
  - b. Technician B
  - c. Both technicians are correct
  - d. Neither technician is correct
121. The main function of a universal joint is to \_\_\_\_\_.
- a. Decrease the hump in the vehicle floor
  - b. Permit the driving force to be transmitted through an angle
  - c. Provide a place to grease the drive shaft
  - d. Provide a way to disassemble the drive line
122. The maximum U-joint angle, in degrees, for a two-piece propshaft is \_\_\_\_\_.
- a. Four
  - b. Three
  - c. Two
  - d. One



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123. Which of the following specifications would ensure proper U-joint cancellation in two-piece propshaft systems?
- a. Second and third working angles should be within  $\frac{1}{2}$  degree of each other
  - b. Angle of the odd joint must be between  $\frac{1}{2}$  and 1 degree
  - c. No U-joint angle should exceed 3 degrees
  - d. U-joints at each end should be within 4 degrees of each other
124. In addition to phasing, which of the following must be done on a two-piece propshaft system before measuring and adjusting driveline angles?
- a. Check for excessive lateral force
  - b. Check tire for uneven bead seat
  - c. Ensure proper lateral alignment
  - d. Remeasure assembly runout
125. What is the middle working angle, in degrees, if the front propshaft measurement is 4 degrees, the rear propshaft measurement is 4  $\frac{1}{2}$  degrees and rear pinion yoke bearing is 2 degrees?
- a. 2
  - b. 1
  - c.  $1\frac{1}{2}$
  - d.  $\frac{1}{2}$
126. The second and third working angles must be within how many degrees of each other for effective cancellation to be possible?
- a. 2
  - b.  $1\frac{1}{2}$
  - c. 1
  - d.  $\frac{1}{2}$
127. Which of the following causes launch shudder in front-wheel-drive vehicles?
- a. Damaged outer constant-velocity joint
  - b. Excessive runout
  - c. Front trim height set too high
  - d. Worn hub and bearing assembly

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128. Which of the following is NOT a factor which interferes with proper U-joint cancellation?
- a. Improperly installed U-joints
  - b. Incorrect driveline working angles
  - c. Excessive runout
  - d. Incorrect phasing
129. Technician A states that phasing of propshafts is only inspected on two or more piece propshaft systems. Technician B states that phasing of propshafts is only inspected on one piece propshaft systems. Which technician is correct.
- a. Technician A
  - b. Technician B
  - c. Both technicians are correct
  - d. Neither technician is correct
130. Which of the following produces smooth and constant power flow through the driveline?
- a. One U-joint orientation is same as other
  - b. Transmission driving front yoke of propshaft is smooth and constant
  - c. Both U-joints slowing down and speeding up at the same time
  - d. There is proper cancellation of U-joints
131. To obtain an accurate rear working angle measurement using an inclinometer, the following statements are true EXCEPT \_\_\_\_\_.
- a. The bearing cap on the propshaft must be straight up and down
  - b. The rear pinion yoke bearing cap must be straight up and down
  - c. Subtract the smaller measure from the larger measure to obtain the u-joint working angle
  - d. Add the two measures to obtain the u-joint working angle

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132. How many degrees must the propeller shaft be rotated after obtaining a measurement from the shaft front bearing cap and before measuring the front slip yoke bearing cap?
- a. 180
  - b. 120
  - c. 90
  - d. 60
133. The working angles on a one-piece propshaft should not exceed \_\_\_\_\_ degrees.
- a. Five
  - b. Four
  - c. Three
  - d. Two
134. How many working angles are present in a two-piece propshaft?
- a. Four
  - b. Three
  - c. Two
  - d. One
135. Why should an axle equipped with composite leaf springs never be shimmed?
- a. The axle and composite leaf spring is a matched set
  - b. There is no provision for shimming
  - c. The leaf springs may be damaged or broken
  - d. The shims may fall out
136. In a two-piece driveshaft system, the maximum working angle that the odd joint must be kept at or below is \_\_\_\_\_.
- a. 2 degrees
  - b. 1½ degrees
  - c. 1 degree
  - d. ½ degree

