Transportation
TTJ-3

Engine Operation & Control Systems TTJ3C

Project Outline

By the end of this project students will be able to explain the four stroke cycle and know the various firing orders. Students will understand the importance of valve timing and be able to explain the principles behind valve operation and adjustments. Students will explore the importance of ignition and fuel injector timing and its effect on engine performance. At the end of this unit, students will build a “Spin Wheel” and be able to articulate what stroke and engine is based on observing the valve train which will demonstrate their understanding of all the concepts as it applies to engine timing.

Activity #1 The four Stroke Engine

In this activity, students will review the 4-stroke cycle.

1. Complete a glossary of terms which includes the following: Stroke, Cycle, RPM, Combustion, P.S.I., TDC, BDC, Vacuum, and Air & Fuel Mixture.
2. Complete the chart on the next slide by filling in the correct terminology.

Stroke	Piston Direction	Valve Operation	Event *(What is happening?)*	Cylinder Pressure	Degrees Crankshaft

Using the chart on the previous slide, summarize and condense your answers into the chart below.

<table>
<tr><td rowspan="2">Degrees</td><td colspan="2">360°</td><td colspan="2">360 °</td><td rowspan="3">720 °</td></tr>
<tr><td>180 °</td><td>180 °</td><td>180 °</td><td>180 °</td></tr>
<tr><td>Stroke</td><td></td><td></td><td></td><td></td></tr>
</table>

Activity # 2 Firing Order

This activity will identify different cylinder configurations and how they relate to manufacturers specific firing orders.

1. Make a list of typical firing orders used by the following vehicle manufacturers Toyota, Chevrolet, Ford, Honda and Volkswagen.
2. Your list should include 4, 6 and 8 cylinder configurations along with at least 3 different firing order sequences.
3. List the most common 4 cylinder firing order.
4. Complete the charts on pg 7 &8 firing orders for a 2 cylinder engine and four cylinder engine.

Complete the following firing orders for a 2 cylinder engine and four cylinder engine.

Two Cylinder- Firing Order 1, 2

Cylinder	180 °	180 °	180 °	180 °
1				
2				

Four Cylinder – Firing Order

Cylinder	180 °	180 °	180 °	180 °
1				
2				
3				
4				

A Spin Wheel Chart

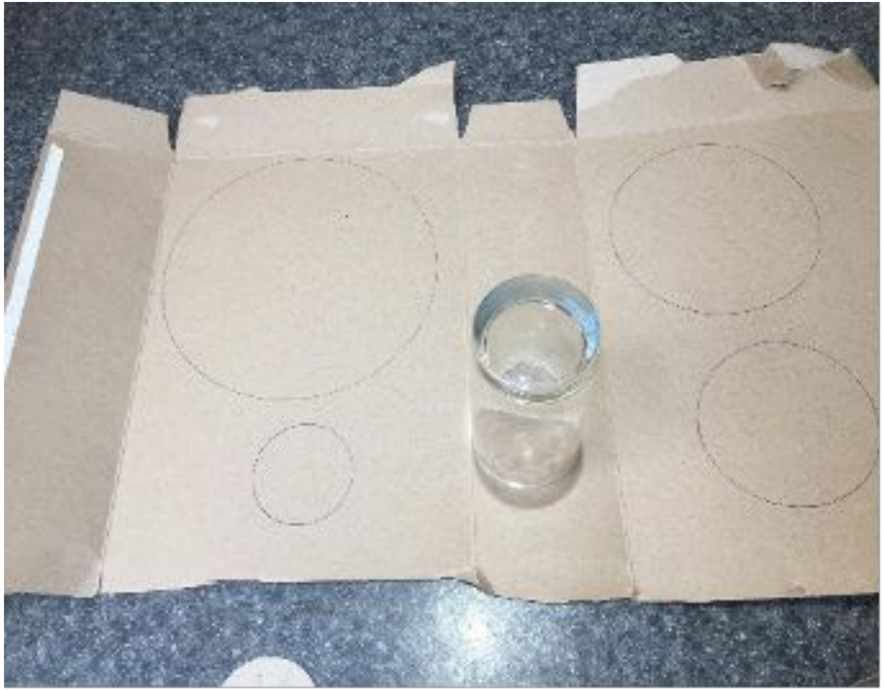
This activity will reinforce engine terminology while creating a Spin Wheel. For this exercise, you will need scissors, a ruler, thumb tack, and a cereal box.

Using a cereal box, open the cereal box at the seams.

1. Trace a circle using a serving plate or any other object that has a similar size. (16 cm in diameter)

Trace a second circle 12 cm in diameter.

Trace the last two circles with a 9 cm and 5.5 cm diameters.



Label the largest circle (16mm)

"Cylinder Firing Order",

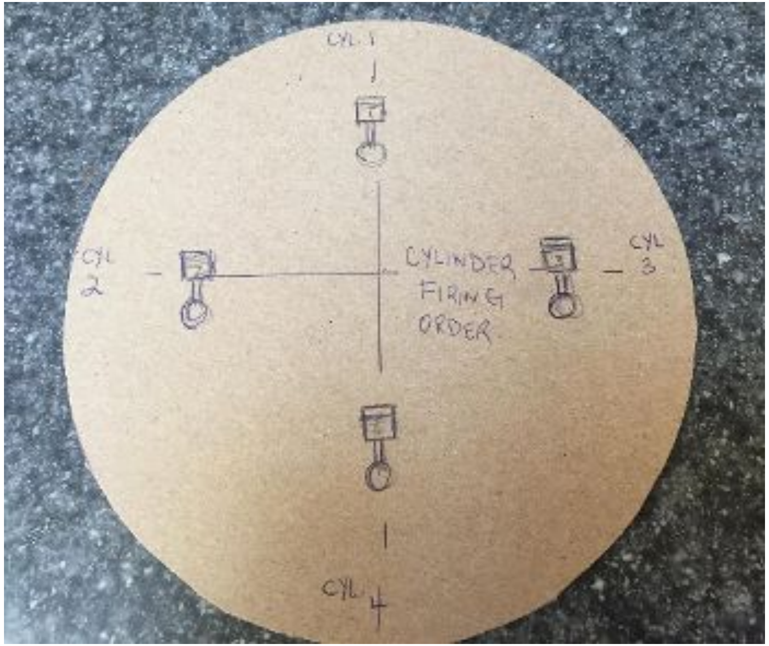
12mm circle "Ignition Timing", 9mm circle "Four Stroke Cycle", 5.5mm circle "Injector".

After all the circles have been labelled, cut out circles with a pair of scissors.

Next, stack all the cut out circles on top of each other and poke a hole in the middle. Then mark 0°, 90°, 180° and 270° with hash marks. Thumbtack works best for creating a hole.

Locate the 16mm circle.

- At the 12 o'clock position label "Cylinder #1",
- 3 o'clock position label "Cylinder #3
- 6 o'clock position label "Cylinder #4
- 9 o'clock position label "Cylinder #2
- Add pistons and connecting rods to your first wheel for added effect to represent each piston.



Locate the 9cm circle that has been labelled “Four Strokes

Trace the smaller 5.5cm circle onto the 9cm circle. Using the hash marks, divide the outer circle into quarters. In each quarter, write in, “Intake, Compression, Power and Exhaust” paying attention to the correct order.

Affix the two circles together

Understanding Engines

This activity will reinforce the principles of engine operations and engine timing. Using the Spin Wheel that you have assembled, pin the wheel in your hand and observe which cylinder is on which stroke.

Answer the following questions below:

1. Spin the inner wheel until cylinder number one is on the Power stroke. What strokes are cylinders numbers 2, 3 and 4 on?
2. If cylinder #3 is on the intake stroke, what is cylinder #3 on?
3. While cylinder #4 is on the compression stroke, what is cylinder #1 on?

Now that we understand that not all cylinders are on the same stroke at the same time on a four cylinder engine, let’s examine valve timing.

1. What is Valve Timing?
2. What does VVT stand for?
3. What does the term valve adjustment mean?
4. What is the difference between an adjustable and hydraulic valve design?
5. List 5 current manufacturers that still require valve adjustment. (You can use any four stroke cycle engine)
6. Explain in detail how to adjust valves on either an adjustable valve set up or hydraulic valve engine.

Continuing with your Spin Wheel, on the “Four Stroke” circle, draw in your camshaft lobes for both intake and exhaust valves. (See slide 20) Also add “Ignition/Spark” between the compression and power stroke.

Spin the wheel so that Cylinder #1 is at TDC, paying close attention to the cam lobes.

1. Which Intake and Exhaust valves can be adjusted?
2. Rotate the wheel so that cylinder #3 is at TDC. Paying close attention to the cam lobes, which Intake and exhaust valves can be adjusted?
3. Rotate the wheel so that cylinder #4 is at TDC. Paying close attention to the cam lobes, which Intake and exhaust valves can be adjusted?


INTAKE
EXHAUST
POWER
COMPRESSION
SPARK IGNITION
FOUR STROKE CYCLE


INTAKE
EXHAUST
POWER
FOUR STROKE CYCLE

Engine Timing

In this activity, students will learn about how engine timing is used to achieve optimal engine performance.

Answer the following questions:

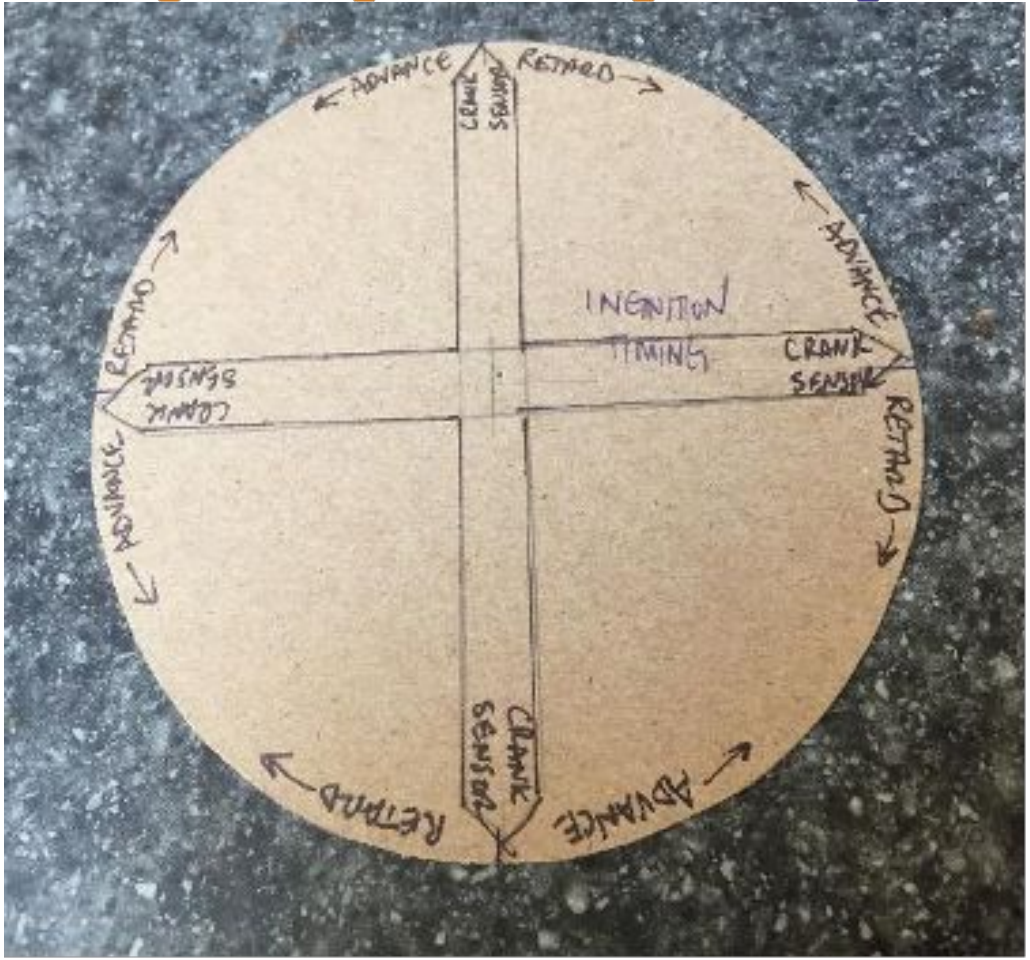
1. What is engine timing?
2. What does the term BTDC mean?
3. Why is advance and retard necessary?
4. What is a crank position sensor?
5. Where is it located on an engine?
6. Locate an image of a crank position sensor from the internet and attach it to this document.
7. Locate the 12cm Spin Wheel labelled “Ignition Timing”.

8. Using the hash marks previously drawn as reference, continue drawing two sets of lines that are perpendicular to each other.

9. On the ends of each set of perpendicular lines, complete the lines so that they meet to form a point.

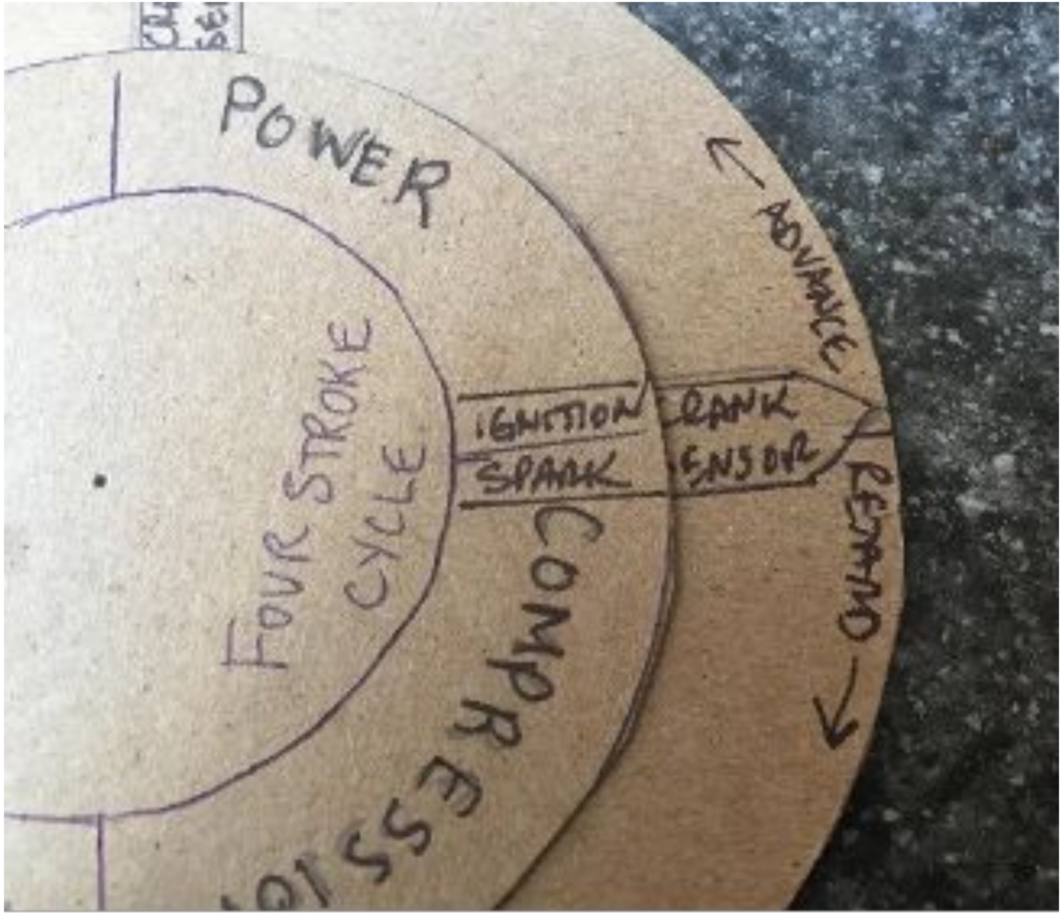
10. At the end of each point, write in “Crank Sensor”.

11. On the left side of each point, label the term “Advanced”. On the right side of each point, label the term “Retard”.



ADVANCE
RETARD
CRANK SENSOR
INGNITION TIMING
ADVANCE
CRANK SENSOR
RETARD
ADVANCE
RETARD
CRANK SENSOR
ADVANCE
RETARD
CRANK SENSOR

12. Assemble your “Four Stroke Cycle” and “Ignition Timing” together.
13. Next, attach the “Cylinder Firing Order” wheel to the other two wheels.
14. While holding the “Cylinder Firing Wheel” with the palm of your hand, spin the “Four Stroke Cycle” wheel with your other hand as quickly as possible while advancing and retarding the ignition timing. Move the timing 10˚ to 30˚ in either direction of each cylinder's TDC reference point with your thumb slowly.


POWER
ADVANCE
IGNITION
SPARK
CRANK
SENSOR
RETARD
FOUR STROKE
CYCLE
COMPRESSION

Answer the next four questions pertaining to step #7.

1. What happens to the Ignition Spark when the wheel is advanced?
2. What happens to the Ignition Spark when the wheel is retarded?
3. Every time the “Ignition/Spark” tab aligns with the “Crank Sensor” tab what happens?
4. How would the engine management system use this information to control the engine?

CYL 1
CYL 2
CYL 3
CYL 4
INTAKE
EXHAUST
POWER
COMPRESSION
FOUR STROKE CYCLE
ADVANCE
RETARD
CRANK SENSOR
IGNITION

Fuel Injection Timing

In this activity, students will use terminology to describe the operation of the fuel timing as it applies to the internal combustion engines. This will include explaining the difference between various fuel delivery systems and use terminology to describe the operation of the injected fuel based on engine timing.

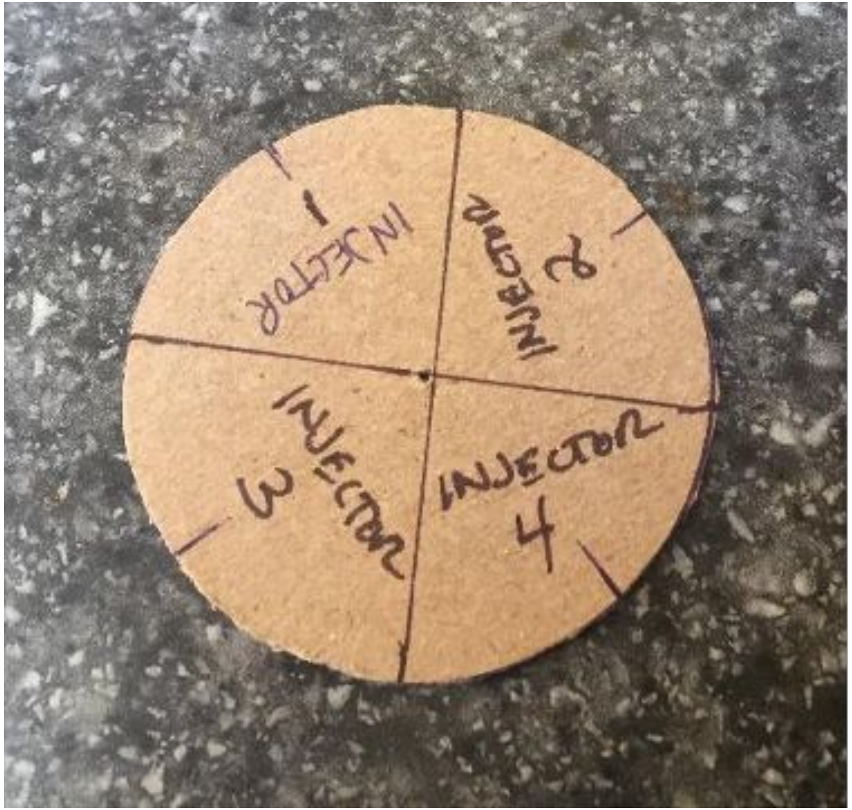
Answer the following questions:

1. Explain the difference between Throttle Body Injection, Multiport (Sequential) Injection and Direct Injection as it applies to the internal combustion engine.
2. Where are fuel injectors located and what function do they perform?
3. State the purpose and location of the cam position sensor.

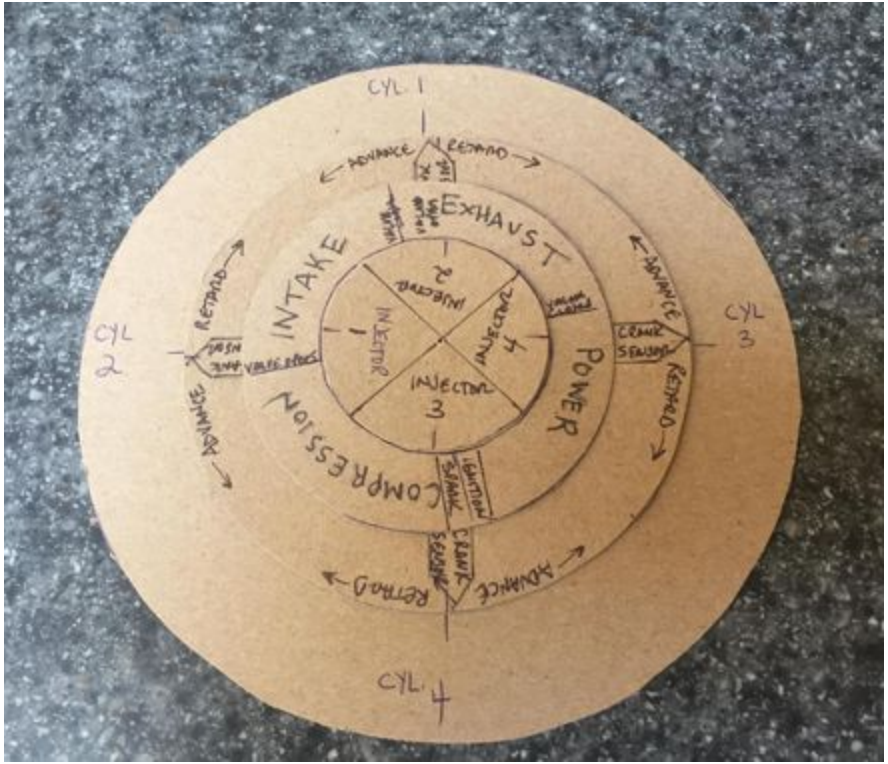
Locate the 5.5cm diameter Spin Wheel labelled Injector.

1. Using a ruler, divide the wheel into quarters.

2. Label each quarter, “Injector 1”, Injector 2”, Injector 3 and Injector 4.



Place the Injector Wheel onto the Spin Wheel.



Now you are complete! Go through all 4 strokes.

Start with cylinder #1 on TDC, ready to spark now add some spark advance. Observe the other cylinders. What stroke are they on?

Answer the next three questions

1. With Piston #1 at TDC, which cylinder is ready to spark next?
2. What stroke is it on now?
3. Spin the Injector wheel and set it to the correct position. Where is Injector 1, 2, 3, and 4 located using the four stroke cycle as reference?

Rubrics, career connections, answer keys and more information:

In depth resources for Engine Operation & Control Systems can be found at: https://www.octe.ca/en/resources/resource-folder/class-lessons/ttj-lessons/ttj3c-transportation-technology