**Description**

This Activity Plan will enable students to identify the differences between metric and imperial bolts (cap screws). They will learn how to measure a bolt and determine the thread type by using a thread gauge. Students will also be taught how to drill a hole and tap a thread into a piece of soft metal. After making the threads, they will be shown the causes of stripped threads and how to strip those threads. After the destruction of the threads the students will be shown a thread repair method by installing a product called a *HeliCoil insert*.

**Lesson Outcomes**

The student will be able to:

- Make threads in a piece of aluminum and then strip the threads to allow for a new thread insert to be installed.
- Identify metric and imperial bolts by their designation marks
- Use a thread gauge to identify the different types of thread pitches

**Assumptions**

Students have little or no previous knowledge or skill in the material being covered.

**Terminology**

Any terminology used will be explained as required during the activity.

**Estimated Time**

2 hours

**Recommended Number of Students**

20, based on the *BC Technology Educators’ Best Practice Guide*

**Facilities**

Shop space with bench space and a metal work vise for each group pair (12 stations)
Tools

- Metalwork vises
- Sufficient hammers and centre punches
- A drill press, if students have previously been taught how to safely operate it
- Hand drills to drill aluminum strips, with drill bits sized to match the threads being tapped
- Threading oil or lubricant
- Tap and die sets sufficient for the class size being taught
- Torque wrench
- Thread gauge

Materials

- A 1" x 1" x ¼" piece of aluminum flat bar for each student
- Selection of bolts of various types, threads and sizes for demonstration examples
- Sufficient bolts for students to match to the threads being tapped in the aluminum strip

Introduction: Common Types of Nuts and Bolts

Vehicles contain many different styles and types of nuts and bolts. Below is a list of common types of nuts and bolts that students should become familiar with.

Hex or flat nut: general usage

Lock nut (Nylock nut): used for safety reasons when a nut should not come loose due to vibrations. Lock nuts are often found on front wheel drive axles or exercise equipment.

Taper nut: used to help centre objects, for example on the wheel of a car

Slotted or castle nut: used in conjunction with a cotter pin on objects that turn or twist, for example on a tie rod or ball joint

Cap or acorn nut: used to give a finished appearance by covering the end of the thread

Wing nut: used when only hand tightening is needed

Cap screw: often referred to as a bolt

Thumb screw: used when only hand tightening is needed

Set screw: used to secure objects without the head protruding, for example on a pulley so the belt does not rip

U bolt: used to secure objects to a shaft, for example springs to the differential

Note: Students may benefit from a safety discussion pertaining to the use of tapered lug nuts and torque patterns. See Activity Plan 4: Roadside Survival for more detailed information.
Activity 1: Identifying Bolts

1. Lay out a selection of bolts on the workbench in random order. Have each student select a bolt and describe what markings they see.

2. Have students work together in pairs using a steel rule (not “ruler”—that’s a king) to measure the length and diameter of the bolt they have selected. Each steel rule should be graduated in both scales, as both imperial and metric can be found in Canada.

3. Working from their handout, students should be able to document each bolt they identify for type, length, thread pitch and strength classification.

4. Additional handouts can then be modified and handed out to students as a test page at a later date.

Metric and Standard Sizing

All import vehicles—including both European and Asian models—have metric nuts and bolts. The only exception is older British vehicles (pre-1985), which could have Whitworth, standard or metric sizes.

All domestic vehicles fabricated before 1975—including Canadian and American models—have standard nuts and bolts. In 1975, Canada adopted the metric system. During the transition period between 1975 and 1985, Canadian-made vehicles had a mixture of metric and standard nuts and bolts. Chassis parts and heavy-duty trucks were the last items to completely change. Virtually all new Canadian-made vehicles are now made with metric nuts and bolts. Exceptions include some parts such as transmissions, which may be made in the USA and shipped to Canada to be installed in Canadian vehicles. These may have standard or metric nuts and bolts, as the USA is slowly switching to metric. Make sure you are aware of what type of nut or bolt you are working on. Check the fit of the socket or wrench to make sure it is tight (no wiggle) before attempting to tighten or loosen it.
An easy way to determine if a cap screw (bolt) is standard or metric is to look at the markings on the head. A standard cap screw will have radial line markings on the head. The more lines, the higher the quality and strength of the cap screw. A minimum grade 5 bolt (standard) or 8.8 (metric) is required for all automotive applications.

<table>
<thead>
<tr>
<th>Grade 2</th>
<th>Grade 5</th>
<th>Grade 7</th>
<th>Grade 8</th>
</tr>
</thead>
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<td>4.8</td>
<td>5.8</td>
<td>8.8</td>
</tr>
<tr>
<td>9.8</td>
<td>10.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 1**—Standard cap screw markings

**Figure 2**—Metric cap screw markings

**Figure 3**—Metric and standard cap screws
**Activity 2: Tap a Hole**

1. Cut a 1" piece of aluminum and file the ends smooth to remove any sharp edges.
2. Mark out the centre of the piece of metal and centre punch a mark for the drill bit to locate.
3. Drill the appropriate size hole for the size of tap being used to tap the threads. Refer to a Tap and Drill Chart.

*Note:* The appropriate hole size to be drilled must be smaller than the intended finished size. This is because the tap must have something to cut threads into. Remember: the outside diameter of a bolt includes the crest of the threads. For example, a ¼" bolt has an outside diameter of ¼". If you were to drill the hole ¼", the threads of the bolt (and the tap) would have nothing to grab onto. You must drill the hole slightly smaller so the tap can make threads to the correct ¼" size.

4. Install the appropriate tap into a tap handle.
5. Make sure the tap is straight and perpendicular to the metal.
6. Turn the tap handle one turn clockwise to begin threading the hole.
7. Rotate the tap handle ½ turn counter-clockwise to break the chip being created.
8. Repeat steps 6 and 7 until the hole is completely tapped (or threaded).

**Activity 3: Test Threads**

1. Find a bolt that will fit your newly formed hole.
2. In small increments, use a torque wrench to tighten the bolt into the newly formed hole.
3. Continue to tighten the bolt until the threads strip. This is where the threads fail and the bolt will continue to move but will never tighten. Record the torque reading.
4. A regular nut and bolt of the same size can now be demonstrated using the same process, to show how much more strain can be applied to steel compared with aluminum threads.

**Activity 4: Teacher Demonstration—Install a HeliCoil Insert**

Now demonstrate drilling out the damaged threads and installing a HeliCoil insert. It may be cost-prohibitive for all students to install a thread insert, but it would be best if they were able to do so.
General Instructions for Installing a HeliCoil Insert

HeliCoils are precision-formed screw thread coils of 18–8 stainless steel wire. They are designed to replace damaged threads and to reinforce tapped threads in light materials, metals and plastics. Each coil possesses a tang that is used to drive the insert into a tapped hole. After insertion, the tang is snapped off.

These instructions should be considered guidelines only. Always follow manufacturer’s instructions when installing a HeliCoil insert.

1. **Drill**
   Identify the damaged threads by pitch and size. Drill them out using the specified drill size.

2. **Tap**
   Using the screw thread insert tap, tap the hole to the minimum depth specified to fully install the HeliCoil insert—and the bolt or screw that will be screwed in afterwards.
3. **Install**
   Install the HeliCoil assembly using the appropriate installation tool. The coil should be installed to between one-quarter and half a turn below the top surface of the tapped hole.

4. **Remove Tang**
   Remove the tang to allow the bolt or screw to pass all the way through the insert. Break off the tang with a flat-bottomed punch or the tang breakoff tool provided. Place the tool squarely over the tang and then strike it sharply with a hammer. Tangs on spark plug inserts and HeliCoil inserts with a diameter greater than \(\frac{1}{2}\)" (12 mm), can be removed using needle-nose pliers.

![Inverted HeliCoil insert](image)

*Note the notch at the tang’s base, designed so the tang will break off more easily upon impact when struck with the tang breakoff tool.*

**Resources**

**Thread Repair Using a HeliCoil Insert—RepairEngineering.com**
www.youtube.com/watch?v=Z-uxtue1xKM

**Evaluation Guidelines**

- Each student will be graded on the quality of the thread made in the supplied aluminum bar. *(Note: This should be marked before the thread is stripped.)*

**Handouts**

The handouts can be reused as a test at a later date by deleting relevant information of the thread type and size identification.

**Measurement Test**

Individual skill tests can be arranged by having students physically measure a collection of different bolts, and then sort them by type and size.
Comprehension Test

Have each student explain in writing, in his or her own words:

1. The process and procedure of how to tap a thread
2. The primary reasons how and why a thread is stripped
3. How a thread insert can be used to replace the damaged threads
4. When a thread insert would be used in place of undamaged threads (state several examples)
5. How a torque wrench is used and why it is necessary

How to Use a Tap and Drill Chart

1. Determine the size (diameter) and pitch of thread to be used. This is called the tap size.
2. Find the horizontal row on the chart that has the determined tap size.
3. Find the appropriate drill size on the same row. Note: An alternate drill size is often given, due to the fact that drill sizing can be denoted in a number of different ways—mm, fractions (inches), letters and numbers.

Example 1—Metric (Figure 6)
M3.5 x 0.6 requires a 2.9 mm or #32 drill bit.

If a chart is not available, the usual rule of thumb is to use the next size smaller drill bit.

<table>
<thead>
<tr>
<th>Tap Size</th>
<th>Tap and Drill—Metric Chart Drill Size (mm)</th>
<th>Drill Size (inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1.6 x 0.35</td>
<td>1.25</td>
<td>#55</td>
</tr>
<tr>
<td>M2 x 0.4</td>
<td>1.60</td>
<td>#52</td>
</tr>
<tr>
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<td>2.05</td>
<td>#46</td>
</tr>
<tr>
<td>M3 x 0.05</td>
<td>2.50</td>
<td>#39</td>
</tr>
<tr>
<td>M3.5 x 0.6</td>
<td>2.90</td>
<td>#32</td>
</tr>
<tr>
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</tr>
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<td>#19</td>
</tr>
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<td>5.0</td>
<td>#8</td>
</tr>
<tr>
<td>M8 x 1.25</td>
<td>6.8</td>
<td>H</td>
</tr>
<tr>
<td>M8 x 1</td>
<td>7.0</td>
<td>J</td>
</tr>
<tr>
<td>M10 x 1.5</td>
<td>8.5</td>
<td>R</td>
</tr>
<tr>
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</tr>
<tr>
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<td>10.2</td>
<td>13/32</td>
</tr>
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<td>27/64</td>
</tr>
<tr>
<td>M14 x 2</td>
<td>12.0</td>
<td>15/32</td>
</tr>
</tbody>
</table>

Figure 7—Example of drill bit size chart for metric taps
Example 2—Imperial; also known as “standard,” or inches (Figure 7)
A \( \frac{3}{8} \) – 18 tap size requires a .2570” or “F” drill bit (in this case, a .2500” or \( \frac{1}{4} \)” would suffice).

![Drill Bit Size Chart](image)

**Figure 8**—Example of drill bit size chart for imperial taps