01 Math Review

Engineering Statics, STCS 200

Updated on: August 13, 2025

Statics and Math

- Statics is all math! All but the most trivial statics problems require algebra and/or trigonometry and/or geometry to solve.
- The good news is that the math is not very difficult. You won't need anything more advanced than high-school math.
- We will do a quick review here that should cover all the math you'll need for STCS 200.

Trigonometry

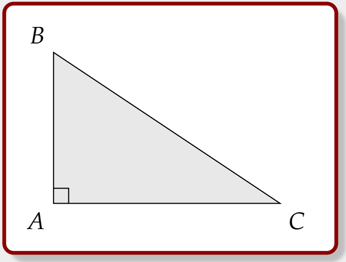
Triangles are a strong, stable shape and often used in engineering.

Triangles help avoid issues like this:

Triangles mean we need trigonometry.

Right Triangle

A **right triangle** is a triangle having one 90° angle.



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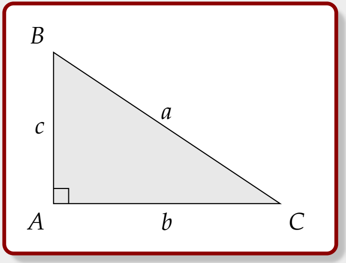

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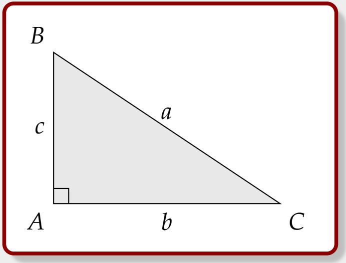


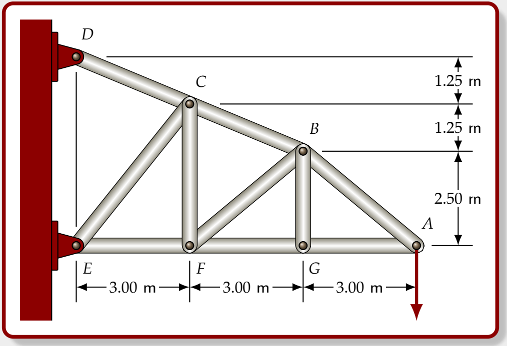
Label the three sides a, b and c. The side a, opposite the right angle, is called the **hypotenuse**.

If we know the lengths of any two sides, we can calculate the length of the third side using the **Pythagorean Theorem**:

Pythagorean Theorem

$$a^2 = b^2 + c^2$$

Right Triangle Exercises (1)



1. Use the Pythagorean Theorem to determine the lengths of CE and CB

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  It is **extremely important** to recognize that we can get no more accuracy out of a calculation than we put in. If the inputs to a problem have three significant digits, we cannot expect any higher accuracy than three significant digits in our result — even if the calculator does give ten digits.

Significant Digits

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Non-zero digits **are** significant:

- 1234 has 4 significant digits.
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Zeros between non-zero digits are significant

- 12034 has 5 significant digits.
- 12.0034 has 6 significant digits.

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- 0.0001234 has 4 significant digits.

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Trailing zeros (after a decimal point) **are** significant

- 1234.0 has 5 significant digits.
- 1.23400 has 6 significant digits.

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  - What if 12300 mm refers to 12.300 m? Then it has 5 significant digits.

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  - What if $12300\,\mathrm{mm}$ refers to $12.300\,\mathrm{m}$? Then it has 5 significant digits.
- Usually, the trailing zeros are placeholders for the magnitude of a value and we don't need to worry unduly.
- If we want to emphasize that 12300 has 4 significant digits, we can write $1.230 \times \left(10^3\right)$.

Calculations for Exercises

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- Intermediate calculations will accumulate rounding errors quickly if we use only three significant digits and these can affect the final result. **For intermediate calculations, use 5 or more significant digits.**

  (When I write solutions down, I use 5 significant digits for intermediate calculations. You may use more if it is more convenient for you, e.g., if you are storing intermediate results in your calculator.)

- When using five significant digits for intermediate calculations, it is necessary to convert to three (or four) significant digits when providing the final answer to an exercise. Then, **rounding** is often involved:

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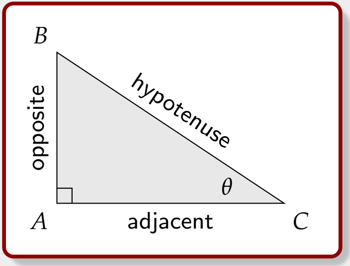
- When the first discarded digit is a 5 (or higher), round up the digit before the 5 (or higher)
- There are various rules (such as the odd-even rule) which take a more complicated approach to rounding 5 but, for our purposes, **5 rounds up**!

More About Right Triangle

The sine, cosine and tangent trigonometrical functions relate an acute angle (θ, in this example) in a right triangle to two of the sides of the triangle.



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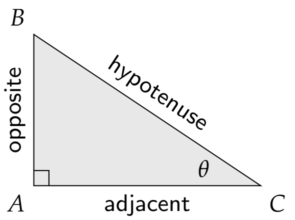
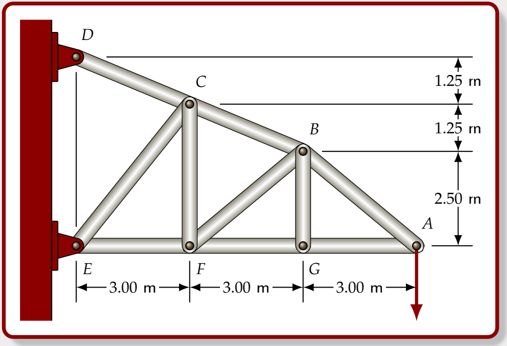


Right Triangle Trigonometry Formulæ

$$\sin\theta = \frac{\textbf{o}\text{pposite}}{\textbf{h}\text{ypotenuse}}, \quad \cos\theta = \frac{\textbf{a}\text{djacent}}{\textbf{h}\text{ypotenuse}}, \quad \tan\theta = \frac{\textbf{o}\text{pposite}}{\textbf{a}\text{djacent}}$$

Remember: **SOHCAHTOA**

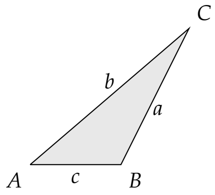
Right Triangle Exercises (2)



2. Use the **tangent** function to calculate $\angle CEF$.
3. From $\angle CEF$ just found (**use the intermediate, 5 or more significant digit, form!**) and the **sine** rule to verify the length of CE found earlier.
4. Use the **cosine** function and the length of CB found earlier to calculate the angle between BC and the horizontal.
5. Use the **tangent** function to verify the previous result.

Triangles - Sine Rule

Not all triangles contain a right angle. To solve for these triangles (finding the lengths of the side and the triangle angles), we have to employ some different tools: the **sine rule** and (later) the **cosine rule**



Sine Rule

$$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$$

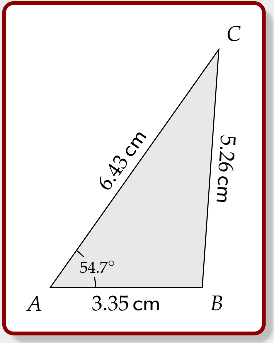
or

Sine Rule

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

Triangles - Sine Rule Exercises

6. Using the sine rule, find $\angle ACB$.
7. Using the sine rule, find $\angle ABC$.
8. Sum the interior angles of the triangle.



Trig Identities

A couple of trig identities that will come in useful:

Identities

$$\sin(180^\circ - \theta) = \sin\theta$$
$$\cos(-\theta) = \cos\theta$$

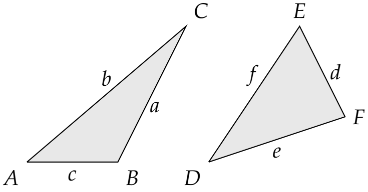
Note:

$$\begin{array}{rcccl} \sin(140^\circ) & = & \sin(40^\circ) & = & 0.64279 \\ \cos(42^\circ) & = & \cos(-42^\circ) & = & 0.74314 \end{array}$$

Thus, we have to be careful when using inverse trigonometric functions:

$$\begin{array}{rcccc} \sin^{-1}(0.64279) & = & 40^\circ & \text{or} & 140^\circ \\ \cos^{-1} 0.74314) & = & -42^\circ & \text{or} & 42^\circ \end{array}$$

Triangles - Cosine Rule

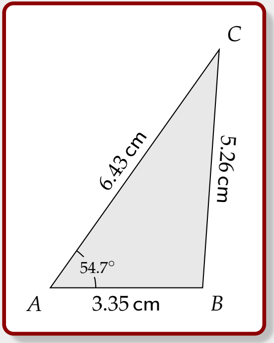


Cosine Rule

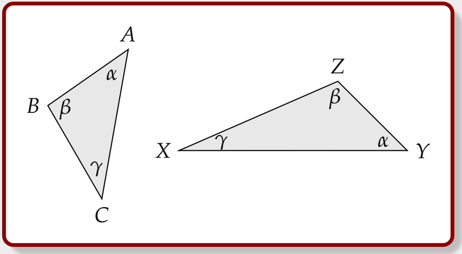
$$a^2 = b^2 + c^2 - 2bc\cos A$$
$$b^2 = a^2 + c^2 - 2ac\cos B$$
$$c^2 = a^2 + b^2 - 2ab\cos C$$

The cosine rule is useful when you have all the sides of a triangle and want to find the angles.

9. Determine $\angle ABC$, using the value for AB found earlier
10. Compare the value for $\angle ABC$ with the value calculated earlier. Is it the same? It should be!



Similar Triangles



If triangles ABC and XYZ have the same angles, they are said to be **similar triangles**.

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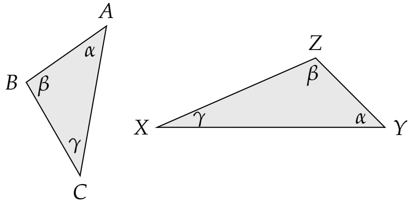


If triangles ABC and XYZ have the same angles, they are said to be **similar triangles**.

The ratios of the lengths of corresponding sides of similar triangles are equal:

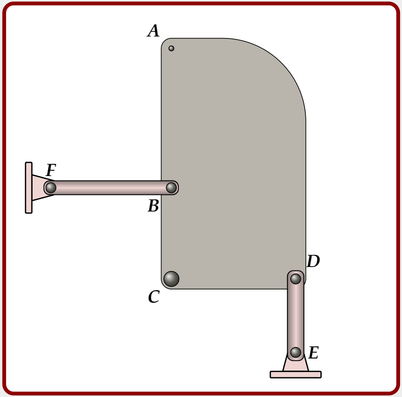
$$\frac{AB}{XY} = \frac{BC}{XZ} = \frac{AC}{YZ}$$

$ABCD$ is a rigid (i.e., it does not deform) plate, pinned at C.

When horizontal force P is applied at A, $ABCD$ rotates about C and A deflects 2.45 mm horizontally rightwards.

Assume that BF remains horizontal and that DE remains vertical.

11. Determine δ_{BF}, the change in length of BF.
12. Determine δ_{DE}, the change in length of DE.



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13. Determine δ_{BF}, the change in length of BF.
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