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# Trade of Metal Fabrication - Phase 2 

Module 4 Unit 2

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## Document Release History

| Date | Version | Comments |
| :--- | :--- | :--- |
| $31 / 01 / 07$ | First draft |  |
| $13 / 12 / 13$ | SOLAS transfer |  |
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|  |  |  |

## Module 4 - Structural Steel Fabrication

## Unit 2 - Connection Between Cross Pipes

Duration - 8 Hours

## Learning Outcome:

By the end of this unit each apprentice will be able to:

- Read and interpret drawing
- Mark out, oxy/fuel cut, assemble, tack and weld a connection bracket between two pipes

Key Learning Points:

| Sk M | Measurement, marking out, oxy-fuel gas cutting, drilling, assembly. |
| :---: | :---: |
| M Sk | Setting out on floor - 3, 4, 5 / 6, 8, 10 method. (Instructor to give practical). |
| M | Application of Pythagoras' Theorem. |
| Rks Sk | Identification of and description of fasteners used in structural steelwork. <br> (For more information see Module 4 Unit 1). |
| Rks Sc | Load bearing capacities. <br> (For more information see Module 4 Unit 1). |
| Rk | Advantages/disadvantages of bolting vs. welding. <br> (For more information see Module 4 Unit 1). |
| Sk | Welding - manual metal arc process, A/C current, D.C. current. |
| Rk Sk | Use of centre lines for assembly. (For more information see Module 3 Unit 11). |
| M | Trigonometric ratios for any $90^{\circ}$ triangle, ratios of common angles ( $30^{\circ}-45^{\circ}-60^{\circ}$ ). |
| B | Quality of work, maintenance of work area, safety awareness. |

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## Training Resources:

- Fabrication workshop facilities, apprentice toolkit, P.P.E.
- M.M.A. plant and consumables
- Material as stated on drawing

Key Learning Points Code:
$M=$ Maths $\quad D=$ Drawing $\quad R K=$ Related Knowledge $S c=$ Science
$\mathrm{P}=$ Personal Skills $\quad \mathrm{Sk}=$ Skill $\quad \mathrm{H}=$ Hazards

## The 3:4:5 Right-Angle Triangle

The upper of the two drawings of Figure 1 shows a triangle with sides in the proportion 3: 4: 5. Such a triangle is always a right-angle triangle. This is because:

The square on the hypotenuse is equal to the sum of the squares on the other two sides.

Taking the 3: 4: 5 triangle:
a) The square on the hypotenuse $=5 \times 5=25$.
b) The square on the shortest side $=3 \times 3=9$.
c) The square on the other side $=4 \times 4=16$; and $9+16=25$.

Thus: if the sides of a triangle are $30 \mathrm{~mm}, 40 \mathrm{~mm}$ and 50 mm long, the triangle is a rightangled one.

If the sides are $27 \mathrm{~mm}, 36 \mathrm{~mm}$ and 45 mm in length the triangle is a right-angled one.

Other 3: 4: 5 triangles are found for example in a triangle ABC , in which $\mathrm{AB}=28 \mathrm{~mm}$, $\mathrm{BC}=21 \mathrm{~mm}$ and $\mathrm{AC}=35 \mathrm{~mm}$.
And also in triangle XYZ in which: $\mathrm{XY}=57 \mathrm{~mm}, \mathrm{YZ}=76 \mathrm{~mm}$ and $\mathrm{XZ}=95 \mathrm{~mm}$.


Figure 1 - Right-Angle Triangle
The square on the hypotenuse is equal to the sum of the squares on the other two sides.

## Trigonometric Ratios for $\mathbf{9 0}{ }^{\circ}$ Triangle



Fig. 1


Fig. 2


Fig. 2 shows the most common rightangled triangle.

In Fig. 3 the values 3, 4 and 5 have been divided by 10 , multiplied by 2 and multiplied by 12 to give three other right-angled triangles.

Fig. 4 shows another right-angled triangle.
Be on the look-out for $3,4,5$ and 5,12 , 13 triangles - they are right-angled!

Checking: $13^{2}=169$
$5^{2}+12^{2}=25+144=169$.

Worked Example:
Using Fig. 5, find c when the sides making the right-angle are 10 and 7 .
$7^{2}+10^{2}=49+100=149$
$\mathrm{c}^{2}=149$
$c=\sqrt{ } 149=12.21$
Answer $\mathrm{c}=12.2$

## Trigonometry

## $30^{\circ} / 60^{\circ} / 90^{\circ}$ Right Angled Triangle

Pythagoras' Theorem may be used to evaluate the third side of a right-angled triangle provided the other two sides are known. It does not however give us a method of calculating the angles of the triangle.

Trigonometry deals with the ratio between the sides of a right-angled triangle and it provides a method of calculating unknown sides and angles.
To enable the trigonometrical ratios to be evaluated, the sides of the triangle must be identified in relation to the angle considered. Figure 2 shows the right angled triangle A, B, C.


Figure 2 - Right Angled Triangle ABC

The Hypotenuse is the name give to the longest side which is also the side opposite the right angle. In relation to angle A the side opposite this angle is referred to as the opposite while the near side is referred to as the adjacent.
Consider the $30^{\circ} / 60^{\circ} / 90^{\circ}$ right angle triangle shown in Figure 3 with a Hypotenuse of length 200 mm and a vertical side of length 100 mm . The length of the horizontal side may be found from Pythagoras' Theorem.
Length of horizontal $=\sqrt{ } 200^{2}-100^{2}$


Figure $3-\mathbf{3 0} \% 0^{\circ} / 90^{\circ}$ Right Angled Triangle

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In relation to angle $A$, the opposite is 100 mm while the adjacent side is 173.2 mm . The three important trigonometrical ratios are sine, cosine and tangent and they are usually written Sin, Cos and Tan for short.

Sin of an angle $=$| $\frac{\text { length of opposite side }}{\text { length of hypotenuse }}$ |
| :--- |

Cos of an angle $=\frac{\text { length of adjacent side }}{\text { length of hypotenuse }}$

Tan of an angle $=\quad$| length of opposite side |
| :--- |

length of adjacent side

In the $30^{\circ} / 60^{\circ} / 90^{\circ}$ triangle repeated below.

$$
\begin{aligned}
\operatorname{Sin} \mathrm{A}=\operatorname{Sin} 30^{\circ} & =\text { opposite/hypotenuse } \\
& =100 / 200 \\
& =0.5 \\
& \therefore \text { Sin } 30^{\circ}=0.5 \\
\operatorname{Cos} \mathrm{~A}=\operatorname{Cos} 30^{\circ} & =\text { adjacent/hypotenuse } \\
& =173.2 / 200 \\
& =0.866 \\
& \therefore \operatorname{Cos} 30^{\circ}=0.866 \\
\text { Tan } \mathrm{A}=\operatorname{Tan} 30^{\circ} & =\text { opposite/adjacent } \\
& =100 / 173.2 \\
& =0.5774 \\
& \therefore \operatorname{Tan} 30^{\circ}=0.5774
\end{aligned}
$$

In relation to angle C of the $30^{\circ} / 60^{\circ} / 90^{\circ}$ triangle shown in Figure 3, the opposite is 173.2 while the adjacent is 100 mm .

Sin C =opposite/hypotenuse
Cos $\mathrm{C}=$ adjacent/hypotenuse
Tan C = opposite/adjacent

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## Trigonometrical Tables

One may construct right angle triangles with various angles and then by measurement, determine the trigonometrical ratio. This would be rather cumbersome and would not give very accurate results. Trigonometrical tables with a high degree of accuracy have been developed relating the ratios of Sin, Cos and Tan of any angle in degrees and minutes between $0^{\circ}$ and $90^{\circ}$.

## N.B.

There are 60 minutes (written $60^{\prime}$ ) in 1 degree.

$$
60^{\prime}=1^{\circ}
$$

## Solution of Right Angled Triangles

Trigonometry may be usefully used in the solution of right angled triangles. Consider the right angled triangle ABC shown in the sketch below. The terms opposite, adjacent and hypotenuse have been shortened to opp, adj and hyp respectively.


$$
\begin{array}{ll}
\text { Tan } A= & \text { opp/adj } \\
\text { Sin A }= & \text { opp/hyp } \\
\text { Cos A }= & \text { adj/hyp }
\end{array}
$$

## Aid to Memory

The 3 above expressions may be remembered from the following:

| Tom's Old Aunt | Tan = opp/adj |
| :--- | :--- |
| Sat On Her | Sin = opp/hyp |
| Coat And Hat | Cos = adj/hyp |

In the solution of right angled triangles, an angle and one side may be given and it may be necessary to determine the other two sides of the triangle. The following diagram may be useful in transposing the above formula:


Draw a triangle as shown. Place the opp at the apex of the triangle. Sin and hyp are placed underneath. To determine the value of the opp place your finger over opp.

$$
\text { Opp }=\operatorname{Sin} x \text { Hyp }
$$

To determine the hyp place your finger over hyp. The hyp equals the opp over Sin.

$$
\mathrm{Hyp}=0 \mathrm{pp} / \mathrm{Sin}_{\mathrm{Sin}}
$$



To determine Sin, place your finger over Sin, this gives the value of Sin equal to opp over hyp.



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## Example 1

Determine the dimensions h and x for triangle ABC shown below.


## Solution to Example 1:


$\sin A=\operatorname{Sin} 15^{\circ}=0.25882$
$h=100 \times \operatorname{Sin} A$
$=100 \times 0.25882$
$h=\underline{25.882} \mathrm{~mm}$
$\operatorname{Cos} A=A d j / H y p=x / 100$

$\operatorname{Cos} A=\operatorname{Cos} 15^{\circ}=0.96593$
$x=100 \times \cos A$
$=100 \times 0.96593$
$x=96.593 \mathrm{~mm}$

## Example 2

The figure shown below shows the outline of a plate in which a slot must be accurately market out, estimate the values of the dimensions $\mathrm{h}, \mathrm{H}, \mathrm{x}, \mathrm{X}$.


## Solution to Example 2:

Using the Zeus Chart Tables:


From tables $\operatorname{Sin} 50^{\circ}=0.76604$

$$
\begin{aligned}
\operatorname{Sin} 50^{\circ} & =0.76604=h / 100 \\
h & =100 \times 0.76604=76.604 \mathrm{~mm} \\
H & =20+76.604=\underline{96.604} \mathrm{~mm}
\end{aligned}
$$


$\begin{aligned} \cos 50^{\circ} & =0.64278=x / 100 \\ x & =100 \times 0.64278=64.278 \mathrm{~mm} \\ x & =30+64.278=94.278 \mathrm{~mm}\end{aligned}$

## NB

The Cos tables are read from the right hand column of the Sin tables. The degrees increase as one moves upwards.

## Use of Calculator

Your calculator will have the keys Sin, $\operatorname{Cos}$ and Tan and these keys may be used to find the value of Sin, Cos or Tan of any angle.

## NB

Make sure the sign Deg is displayed near the top left corner. To find $\operatorname{Sin} 30^{\circ}$, key in 30 $\operatorname{Sin}$. The result is 0.5 , hence $\operatorname{Sin} 30^{\circ}=0.5$.

Similarly, to find the $\operatorname{Cos} 55^{\circ}$, key in $55 \operatorname{Cos}$, the result is $0.5735764=0.5736$, correct to four decimal places.

## Test Yourself

(A) Use you calculator to find the following correct to four decimal places.
(i) $\operatorname{Sin} 56^{\circ}$
(iv) $\operatorname{Cos} 20^{\circ}$
(ii) $\operatorname{Cos} 34^{\circ}$
(v) $\operatorname{Sin} 70^{\circ}$
(iii) $\operatorname{Tan} 86^{\circ}$
(B) The length of the hypotenuse $A C$ is 150 mm and angle $\mathrm{C}=34^{\circ}$, calculate the length of $A B$ and $B C$.


## Answers:

A)
i. 0.8290
iv. 0.9397
ii. 0.8290
v. 0.9397
iii. 14.3007
B)


Length $A B=0.5592 \times 150$
$=83.88 \mathrm{~mm}$


$$
\begin{aligned}
\text { Length } B C & =0.8290 \times 150 \\
& =\underline{124.35} \mathrm{~mm}
\end{aligned}
$$

## NB

When using your calculator to find the $\operatorname{Sin}, \operatorname{Cos}$ and Tan of angles expressed in degrees and minutes, it will be necessary to convert the angle expressed in degrees and minutes into decimal form.

Remember 60 minutes $\left(60^{\prime}\right)=1$ degree $\left(1^{\circ}\right)$.

## Example:

Express the angles $5^{\circ} 24^{\prime}$ and $10^{\circ} 40^{\prime}$ in decimal form.

## Solution:

$$
\begin{aligned}
5^{\circ} 24^{\prime}, 24^{\prime} & =24 / 60 \text { part of a degree } \\
& =0.4 \text { degrees } \\
5^{\circ} 24^{\prime} & =5.4^{\circ} \\
& \\
10^{\circ} 40^{\prime}, 40^{\prime} & =40 / 60 \text { part of a degree } \\
& =0.666 \text { degrees } \\
& \\
10^{\circ} 40^{\prime} & =10.666^{\circ}
\end{aligned}
$$

When a calculation is completed it may be necessary to convert the degrees in decimal form to degrees and minutes. This may be achieved by simple multiplying the number(s) to the right of the decimal point by 60 .

## Example:

Express the angles $8.72^{\circ}$ and $20.33^{\circ}$ in degrees and minutes.

## Solution:

$0.72 \times 60=43.2$,
$8.72^{\circ}$
$=8^{\circ} 43^{\prime}$
$0.33 \times 60=19.8$,
$20.33^{\circ}$
$=20^{\circ} 20^{\prime}$

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## Self Assessment

Questions on Background Notes - Module 4.Unit 2

## No Suggested Questions and Answers.

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