Literacy Northwest
Regional Literacy & Basic Skills Network

OALCF Tasks for the Apprenticeship Goal Path: Prepared for the Project, *Developing Best Practices for Increasing, Supporting and Retaining Apprentices in Northern Ontario (2014)*

OALCF Task Cover Sheet

Task Title: Calculating Working Load Limit for Hoisting and Rigging

Learner Name:
Date Started: **Date Completed:** **Successful Completion:** Yes___ No___
Goal Path: Employment___ Apprenticeship ✓ Secondary School__ Post Secondary__ Independence__
Task Description: Millwrights must understand how to use calculations to locate the correct sizes used in lifting and for each piece of equipment used in the lift. *Please note that some tasks within this task set are above a Level 3.*

Competency:	**Task Group(s):**
A: Find and Use Information C: Understand and Use Numbers	A1: Read continuous text A2: Interpret documents C3: Use measures

Level Indicators:

A1.2: Read texts to locate and connect ideas and information

A2.2: Interpret simple documents to locate and connect information

C3.3: Use measures to make multi-step calculations; use specialized measuring tools

Performance Descriptors: see chart on last page

Materials Required:

- Attached document - Understanding Working Load Limits for Hoisting and Rigging
- Pen and paper
- Scientific Calculator

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Learner Information and Tasks

Millwrights determine the angle for the sling, calculate the force of load for each point of the lift, and locate the correct eyebolts, slings and shackles using charts available through the manufacturer or employer. Look at the attached document, **Understanding Working Load Limits for Hoisting and Rigging**.

There are several loads that need to be lifted.

Task 1: Locate and name all the components related to a lift.

Task 2: Calculate the force of load for each component of the lift for the following loads.

a) Load 1 – 3600 lbs - single lifting point
- Sling _____
- Eyebolts _____
- Shackles _____

b) Load 2 – 5500 lbs - 2 leg bridle hitch 60° sling and a 45° eyebolt
- Sling _____
- Eyebolts _____
- Shackles _____

c) Load 3 – 4200 lbs -4 leg bridle hitch 60° sling and a 45° eyebolt
- Sling _____
- Eyebolts _____
- Shackles _____

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Task 3: Locate and list the correct sizes for each piece of rigging equipment used in Task 2. Use the tables provided in the example.

a) Load 1 – 3600 lbs - single lifting point

- Sling _____
- Eyebolts _____
- Shackles _____

b) Load 2 – 5500 lbs - 2 leg bridle hitch 60° sling and a 45° eyebolt

- Sling _____
- Eyebolts _____
- Shackles _____

c) Load 3 – 4200 lbs -4 leg bridle hitch 60° sling and a 45° eyebolt

- Sling _____
- Eyebolts _____
- Shackles _____

Task 4: Calculate the force of load on each leg of the sling using 60°, 45° and 30° angles. The total load weight is 7500 lbs. Explain which angle is better to use for this load.

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Understanding Working Load Limits for Hoisting and Rigging

A minimum of three components are used for Hoisting and Rigging. They include the Eyebolts, Shackles and Slings. There may be more components used depending on the lift. Additionally more than one of each of the components may be used for the lift.

Working Load Limit (WLL) - is used to determine the maximum strength that a component such as the eyebolt, shackle and sling can safely lift the weight of the load.

Formula for the Working Load Limit

WLL = $\frac{\text{Breaking strength}}{\text{Design Factor}}$ = $\frac{\text{Breaking strength}}{5}$	For example, a shoulder eyebolt rated at 1500 lbs. breaking strength has a working load limit of 300 lbs. $\frac{1500 \text{ lbs}}{5}$ = 300 lbs

The load weight is calculated using the load, the slings, shackles and eyebolts.

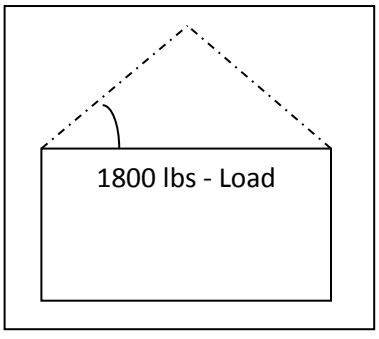
It is important to note that when there are angles used, these affect the WLL.

Once the load weight has been determined then the rigging equipment can be selected based on this.

The following tables are used in determining the correct size of rigging equipment used for a lift.

Note: The tables are sample values only and not to be used except for the purpose of the task outlined below.

The following is an example of a load to be lifted



Step One - Determine the angle of the sling

Load will have 2 lifting points

Distance of 6 ft. between 2 lifting points

Length of each sling is 6 ft.

6 ft. LP + 6 ft. sling + 6 ft. sling = 3 equal sides forming an equilateral triangle therefore each angle is 60°. The sum of all 3 angles in a triangle will always equal 180°.

In this example there is 2 lifting points so the lift will require 2 slings, 2 eyebolts and 2 shackles. The load is 1800 lbs and the approximate weight (this is estimated) of the rigging equipment is 10 lbs for the slings, 30 lbs for the eyebolts and 26 lbs for the shackles. That makes a total weight of 1866 lbs.

Determine the angle of the sling when attached to the load and for lifting. The angle of the sling will determine the Working Load Limit for each component of the rigging equipment.
The angle to be used for the sling will be assessed and determined by you. Most often the angle used is 60°, however, the angles may go lower. Do not go any lower than 45°. ***It is important to note that as the angle decreases the force of load increases exponentially.***

Step Two - Calculate the correct sling to use

To determine which sling to use the weight of the load must be known.

In this example the load weight is 1800 pounds.

Refer to the table to locate the size of the sling for the load of 1800 lbs

Convert 1800 lbs to tons (1800 ÷ 2000 = .9)

Locate the angle of the sling

Locate the safe load in tons within the column with the correct angle of the sling

Locate the corresponding nominal size for the load and sling angle

You now have the correct sling to be used.

The chart indicates the size of sling should be 5/16".

Note: .9 x 2000 lbs (1 ton) = 1800 lbs

Slings - Safe Load in Tons

Nominal Size	Single	Choker	U-sling	Basket	60- deg	45-deg	30-deg
1/4	.5	.3	.7	.6	.57	.5	.3
5/16	.8	.6	1.1	1.0	.9	.7	.6
3/8	1.1	.8	1.5	1.4	1.3	1.1	.8
1/2	2.0	1.4	2.7	2.4	2.3	1.9	1.3
5/8	2.9	2.1	4.2	3.8	3.7	3.0	2.1
3/4	4.1	3.0	6.0	5.4	5.2	4.2	3.0
7/8	5.6	3.8	7.7	6.8	6.7	5.4	3.8
1	7.2	5.0	10.0	9.3	8.7	7.1	5.0
1 1/8	9.0	5.6	11.2	10.5	9.7	7.9	5.6

When using eyebolts on the lift they will be attached based on the number of lifts points. For example if the load is a single lift point the eyebolt will be attached straight up and down, if the load has more than one lift point the eyebolts will see an angular force. This is important because it affects the WLL on the eyebolt and ensures that the correct eyebolt is used for the lift. When lifting with more than 2 slings, we have to assume that, at any given point in time, only 2 are carrying the entire load. This is because the sling lengths and the distances between the attachment points may vary. There, the calculation for 4 lifting points is the same as for 2.

Step Three - Determine the correct eyebolt to use

The load weight is 1800 however this is divided into two since there are two separate eyebolts being used.

Refer to the table to locate the size of the eyebolt for the WLL of 900 lbs

Locate the angle of the eyebolt

Locate the safe load in pounds within the column with the correct angle of the eyebolt

Locate the corresponding nominal size for the load and eyebolt angle

You now have the correct eyebolt to be used.

The chart indicates the size of the eyebolts should be 1 1/2"

Drop Forged Steel Shoulder-type Eyebolts

Size			
1/4"	300 lb	30 lb	40 lb
1/2"	1,300 lb	140 lb	150 lb
3/4"	3,000 lb	250 lb	300 lb
1"	6,000 lb	500 lb	600 lb
1 1/4"	9,000 lb	800 lb	900 lb
1 1/2"	13,000 lb	1,200 lb	1,300 lb
2"	23,000 lb	2,100 lb	2,300 lb
2 1/2"	37,000 lb	3,800 lb	4,300 lb

Step Four - Determine the correct shackles to use

For shackles the force of load must be calculated. This is different than the load weight.

Determine the force of the load

This is calculated using the following formula:

$$F = \frac{\text{Load} \div 2}{\text{Sin(angle)}}$$

Use a scientific calculator to determine the Sine(Angle)

$$F = \frac{1800 \div 2}{\text{Sin}(60)} \qquad F = \frac{900}{.866} \qquad F = 1039$$

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Force of Load - The force of pressure, weight, or similar phenomena that is supported by a body or structure.

The information for the WLL for each component is located at the manufacturer's websites or in tables provided by the employer. In the case of the sling it is required to be labelled on the sling. For example: a sling may be rated for 2000 lbs.

Refer to the table to locate the size of the shackle for the WLL of 1039 lbs

Convert pounds to tons

1039 ÷ 2000 = .5195 ton

Locate the safe load in tons in the table - .8ton

Locate the corresponding nominal size for the shackle

You now have the correct shackle to be used.

The chart indicates the size of the shackles should be 3/8

Anchor Shackles

Nominal Size	Tons Safe Load	Dimensions		
		A	B	C
3/8	.8	1 1/2	1 1/16	7/16
1/2	1.4	2	7/8	5/8
5/8	2.2	2 3/8	1 1/16	3/4
3/4	3.2	2 7/8	1 1/4	7/8
7/8	4.3	3 1/4	1 3/8	1
1	5.6	3 5/8	1 11/16	1 1/8
1 1/8	6.7	4 1/4	1 7/8	1 1/4
1 1/4	8.2	4 3/4	2	1 3/8
1 1/2	11.8	5 1/2	2 1/4	1 5/8
2	21.1	7 3/4	3 1/4	2 1/4

For this example Dimensions has not been included

Dimensions refer to the size of the shackle.

A - Height

B - Width

C- Pin diameter

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Answer Key

Task 1: Read through the attached information and example to locate and name all the components related to a lift.

Slings, eyebolts, and shackles

Task 2: Calculate the load and force of load for each component of the lift for the following loads.

a) **Load 1 – 3600 lbs - single lifting point**
   - **Sling 3600 lbs**
   - **Eyebolts 3600 lbs**
   - **Shackles - 3600 lbs**

b) **Load 2 – 5500 lbs - 2 leg bridle hitch 60° sling and a 45° eyebolt**
   - **Sling - 5500 lbs**
   - **Eyebolts - 2750 lbs**
   - **Shackles - 3175.5 lbs rounded to 3176 lbs**

c) **Load 3 – 4200 lbs -4 leg bridle hitch 60° sling and a 45° eyebolt**
   - **Sling -4200 lbs**
   - **Eyebolts - 2100 lbs**
   - **Shackles - 2424.9 lbs, rounded to 2425 lbs**

Task 3: Locate and list the correct sizes for each piece of rigging equipment used in Question 2. Use the tables provided in the example.

a) **Load 1 – 3600 lbs - single lifting point - Convert pounds to tons**
   - **Sling - 3600 lbs = 1.8 tons = 1/2" nominal size**
   - **Eyebolts - 3600 lbs = 1" size**
   - **Shackles - 3600 lbs = 1.8 ton = 5/8" nominal size**

b) **Load 2 – 5500 lbs - 2 leg bridle hitch 60° sling and a 45° eyebolt**
   - **Sling - 5500 lbs = 2.75 tons = 5/8" nominal size**
   - **Eyebolts - 2750 lbs = 2 1/2" size**
   - **Shackles - 3176 lbs = 1.6 tons = 5/8" nominal size**

c) Load 3 – 4200 lbs -4 leg bridle hitch 60° sling and a 45° eyebolt

- **Sling - 4200 lbs = 2.1 ton = 1/2" nominal size**
- **Eyebolts - 2100 lbs = 2" size**
- **Shackles - 2425 lbs = 1.2 tons = 1/2"**

Task 4: Calculate and compare the force of load using 60°, 45° and 30° angles. The total load weight is 7500 lbs. Explain which angle is better to use for this load?

$F = \frac{7500 \div 2}{\text{Sin}(60)}$ $F = \frac{3750}{.866}$ F = 4330.25

$F = \frac{7500 \div 2}{\text{Sin}(45)}$ $F = \frac{3750}{.707}$ F = 5304.10

$F = \frac{7500 \div 2}{\text{Sin}(30)}$ $F = \frac{3750}{.5}$ F = 7500

The 60 degree angle should be used to lessen the load of force for lifting on each sling. The load may become unstable with the 30 degree angle.

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Performance Descriptors		Needs Work	Completes task with support from practitioner	Completes task independently
A1.2	• scans text to locate information			
	• locates multiple pieces of information in simple texts			
	• makes low-level inferences			
	• follows the main events of descriptive, narrative and informational texts			
A2.2	• performs limited searches using one or two search criteria			
	• extracts information from tables and forms			
	• uses layout to locate information			
	• makes connections between parts of documents			
	• makes low-level inferences			
C3.3	• calculates using numbers expressed as whole numbers, fractions, decimals, percentages and integers			
	• understands and uses properties of angles and triangles to solve problems			
	• manages unfamiliar elements (e.g. context, content) to complete tasks			
	• chooses and performs required operations; makes inferences to identify required operations			
	• selects appropriate steps to solutions from among options			
	• interprets, represents and converts measures using whole numbers, decimals, percentages, ratios and fractions			
	• uses strategies to check accuracy (e.g. estimating, using a calculator, repeating a calculation, using the reverse operation)			

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This task: was successfully completed___ needs to be tried again___

Learner Comments

_____ _____

Instructor (print) **Learner Signature**