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Significant Figures, Rounding, and Solution of a Statics Problem

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A Quick Review

by

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Significant Figures, Rounding, and Solution of a Statics Problem – A Quick Review is a review of significant figures and rounding, and of a basic method used by engineers in solving a statics problem. This course is prepared for those who might find themselves a bit rusty and would like a quick refresher.

The information in the course is useful for application to the solution of structural problems especially in the fields of statics and strength of materials.

The significant figures and rounding review includes a discussion of the precision and validity of an answer, along with rules and guidelines for using the appropriate number of significant figures, and for rounding answers appropriately.

The solution of a statics problem review shows the steps in solving a two dimensional statics problem using the up equals down and the left equals right method of calculation.

SIGNIFICANT FIGURES REVIEW

All answers to arithmetic problems are expected to have a precise answer. The difficulty in applying this simple principle lies in being able to tell the difference between arithmetic precision and the validity of an answer.

In most real-world problems such as statics and strength of materials, only the first few digits of an answer are valid or "significant". This is because dimensions are commonly rounded, loads are only approximate (often specified in the building codes as maximum or minimums), and real world connections, bearings, and geometric configurations are usually simplified. Simplification allows relatively simple calculations to closely approximate the solutions to very complex mathematical equations that represent the real boundary conditions.

With the hand held calculators we have today, it is tempting to write many figures in the answer to an arithmetic problem. However, just because the calculator shows eight figures, doesn't mean that they are all valid. Here's the rule:

> **An answer cannot be more accurate than the least accurate number used in the statement of the problem.**

This principle can be illustrated by computing the area of a 2" diameter circle. Obviously the answer is approximately 3.1415926536 in^2 as shown below.

$$A = \pi r^2 = \pi\left(\frac{2"}{2}\right)^2 = 3.1415926536\, in^2$$

Now, let's say that the diameter of the circle is accurate to three figures (2.00"). That means that the answer cannot be more accurate than three significant figures – which is 3.14 in^2.

Here's why. Because the diameter is accurate to three significant figures – 2.00" – that means that the actual value of the diameter is in the range of 1.995" to 2.005". Therefore, the actual area is somewhere between 3.12595 in^2 and 3.15732 in^2 as shown in the following two calculations.

$$\text{Minimum area} = \pi\, r^2 = \pi\left(\frac{1.995}{2}\right)^2 = 3.12595 in^2 \rightarrow 3.13\ in^2$$
$$\text{Maximum area} = \pi\, r^2 = \pi\left(\frac{2.005}{2}\right)^2 = 3.15732 in^2 \rightarrow 3.16\ in^2$$

Rounding these two values to three significant figures means that the actual area of the circle is between 3.13 in^2 and 3.16 in^2. In fact, the area of the circle could actually be 3.13 in^2, 3.14 in^2, 3.15 in^2, or 3.16 in^2. Originally, we said that the answer was approximately 3.14 in^2 which is still true – we have not contradicted the principle that the answer cannot be more accurate than the least accurate number used in the calculation.

<u>ROUNDING REVIEW</u>

Most values in structural mechanics problems are known with two or three figures of accuracy. It follows that most answers in statics and strength of materials should have two or three figures of accuracy. The widely accepted practice is that all answers have **three significant figures**.

There are a couple of simple exceptions to the three significant figure rule.

- Intermediate values of a calculation can have any number of figures. You are encouraged to carry extra figures through the calculation process, then <u>round the answer</u>.
- Whole number answers need not have the added zeros. An answer of 5 ft is preferred to 5.00 ft, but both are acceptable.
- When two numbers must add to a fixed total, one number may have an added significant figure or the other may have one less significant figure. The fixed total has three significant figures.
  - **<u>Example:</u>** 6.67 + 13.33 = 20.0

    <u>OR</u>

    6.7 + 13.3 = 20.0

When rounding an answer to three significant figures, one occasionally meets the dilemma of a fourth digit that is exactly equal to 5. Should you round up or round down? Both answers are acceptable, but the widely accepted rule is to round to the even number.

Example: Round the answer 1225 to three significant figures.

> Using the widely accepted rule, the answer should be rounded to 1220 instead of 1230. (Because 20 is an even number while 30 is an odd number).

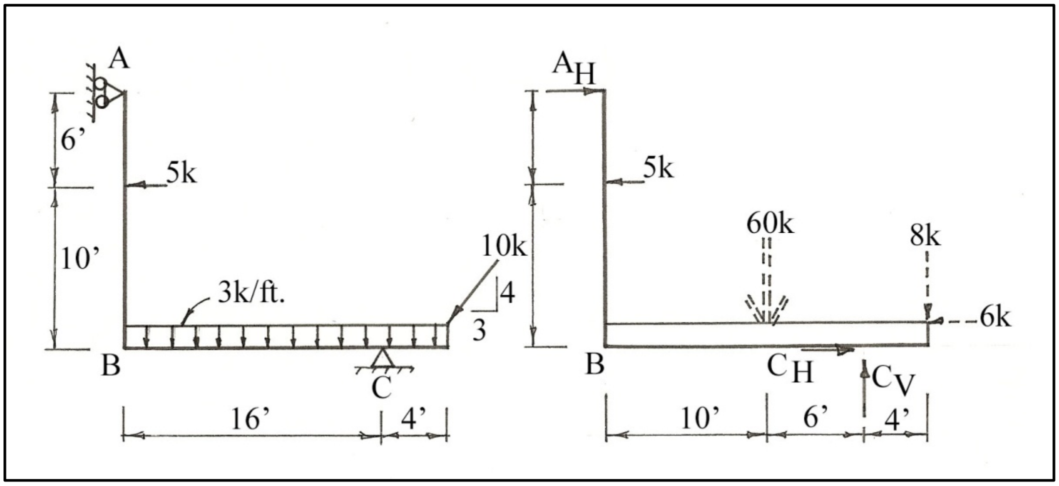
SOLUTION of a STATICS PROBLEM

All of Statics and Strength of Materials is based on equilibrium of a body at rest. In two dimensional systems, the sum of forces in the vertical direction always equals zero. The sum of forces in the horizontal direction always equals zero. And, the sum of the moments at any point always equals zero.

As a quick review of the principles of equilibrium, let's work through a statics problem.

Example: What are the reactions at support A and support C?

The first step is to draw a complete free-body diagram of the entire structure. Replace the reactions with their unknowns and resolve each load into its x- and y-components. Don't worry about the direction you choose for the reactions. If you choose the wrong directions, the answer will be negative.



Structural System Free-Body Diagram

Notice in the Free-Body Diagram that the roller support is replaced with a single force acting perpendicular to the support surface. And the pin support is replaced with a horizontal and vertical force. There are no moments resisted by the supports.

Also notice that the 3 kip/ft uniformly distributed load has been replaced by a concentrated force acting at its centroid - i.e., at 10 feet from each end of the load. And that the 10 kip diagonal force is replaced with its vertical and horizontal component.

Now, we apply the equations of equilibrium to solve for the reactions.

First, sum moments about C equals zero to find A_H. Then sum forces horizontally equals zero to find C_H.

$\sum M @ C = 0$

↶	↷
60 (6')	8 (4')
5 (10')	A_H (16')
410 =	32 + 16A_H
16A_H =	378

$$\boxed{A_H = 23.6 \text{ kips} \rightarrow}$$

$\sum F_H = 0$

←	→
5	A_H=23.6
6	C_H

$11 = C_H + 23.6$

$C_H = - 12.6 \rightarrow$

$$\boxed{C_H = 12.6 \text{ kips} \leftarrow}$$

Notice that the calculated answer for C_H was a negative number to the right (- 12.6 →). The right arrow signifies the original assumed direction for C_H. The negative sign signifies that the assumed direction was wrong. To avoid ambiguity, don't use a negative sign and a directional arrow on the forces and diagrams. Use one or the other, but not both. In this course, we will use arrows. Hence the boxed-in answer is a positive number with an arrow to the left (the correct direction of the horizontal component of the reaction at C).

Next, sum moments about A equals zero to find C_V. And, finally, sum moments about B to check our work.

$\sum M @ A = 0$

↶	↷
C_V (16')	5 (6')
	60 (10')
	(C_H=12.6) (16')
	6 (16')
	8 (20')
$16C_V$ =	1088
C_V = 68.0 kips ↑	

$\sum M @ B = 0$

↶	↷
5 (10')	23.6 (16')
68 (16')	60 (10')
	8 (20')
1,138 =	1,138
Check √ ☺	

The drawing below shows the solution to the problem. The reactions at A and C are shown on the drawing.