

A&AE-190

Numerical Descriptions of Physical Quantities

Including
Scientific Notation
Sanity Checks in Engineering
Jeopardy! Game
Homework 6: Due Thursday, November 8, 2001

References:

Refer to information about unit converters at
<http://roger.ecn.purdue.edu/~andrisan/Courses/AAE190%20Fall%202000/units.html>

Guide for Use of the International System of Units available at
<http://physics.nist.gov/Document/sp811.pdf>

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Numerical Descriptions of Physical Quantities (Including Homework 6)

Scientific Notation

A standard way to present a real number, called **scientific notation**, is obtained by shifting the decimal point and supplying an appropriate power of ten. For example,

$$\begin{aligned}0.0000747 &= 7.47 \times 10^{-5} = 7.47\text{E-}5 \\31.41 &= 3.141 \times 10^1 = 3.141\text{E}1 \\9,700,000,000 &= 9.7 \times 10^9 = 9.7\text{E}9\end{aligned}$$

or in general

$$x = \pm q \times 10^n = \pm q\text{E}n$$

where q is the **mantissa** (and lies in the range $1 \leq q < 10$) and integer n is the **exponent** or power of ten.

Physical Quantities

Physical quantities have both **magnitude** (e.g., 3,8000) and **units** (e.g., light years). In the International System of Units (SI) the unit of length is the meter. In the U.S. Customary of Units the unit of length is the foot.

Examples of Large Physical Quantities

Light year is 6,000,000,000,000 miles (6 trillion) = 6E12 miles.

Distance from Earth to the Moon is 1.2 light seconds = 1.2E0 light seconds

Distance from Earth to the Sun is 8.5 light minutes = 8.5E0 light minutes.

Distance from Earth to Pluto is 5.4 light hours.

Nearest star (Alpha Centauri) to the Earth is 4.2 light years.

Distance Earth to center of our galaxy (Milky Way), 3,8000 light years = 3.8E4 light years.

Our own galaxy is 100,000 light years across, i.e., 1E5 light years.

Distance Earth to nearest galaxy (Andromeda Galaxy) is 2.2 million light years = 2.2E6 light years

Sanity Checks in Engineering

Every time you do an engineering computation you should perform a Sanity or Believability Check on your answer.

If you expect your answer to be a distance, then the physical units of your answer should be a distance measure like feet or meters. Since we work with equations, the physical units of the quantities on both sides of an equation must be equal. For example if you expect your answer to be a distance and you work through an equation and compute the answer to have units of time then you have made a mistake somewhere. Your equation might be wrong or you might have used the wrong units somewhere.

Example: If I am going at 60 miles per hour how far to I travel in two hours?

I expect the answer to be a distance in miles.

Using the wrong formula

$$\begin{aligned}\text{Distance in miles} &= \text{Rate in miles per hour} / \text{Time in hours} \\ &= (60 \text{ miles/hour}) / (2 \text{ hours}) = 30 \text{ miles}/(\text{hour squared})\end{aligned}$$

The problem here is that the units don't work out. You expect the units to be miles. The equation is obviously wrong since your equation is giving the wrong units.

Using the correct formula

$$\text{Distance in miles} = \text{Rate} \times \text{Time} = (60 \text{ miles/hour}) \times (2 \text{ hours}) = 120 \text{ miles}$$

Now the units work out and the formula is correct.

As an engineer you must develop some sense for how large or small you think the answer should be, e.g., the wingspan of my aircraft is 100 feet or 100 million feet or 100 miles.

These ideas give rise to several different Sanity Checks for both magnitude and units.

Sanity Check #1: Is the magnitude or power or ten of my answer believable for the assumed units?

Sanity Check #2: Are the physical units I have derived for the answer correct?

Sanity Check #3: Are the physical units of my answer consistent with the magnitude I expect for the answer?

Sanity Check #4: Are the physical units on both sides of my equation are equal?

Jeopardy! Game: Category: Power of Ten

Like the television game Jeopardy, the answer (also called the clue) is given and the contestant must supply the applicable question (also called the response).

Clue (Answer): This thing is blue.

Response (Question): What is the sky?
or What color is the sky?

For our purposes we will be concerned about clues that involve physical quantities where the magnitude and units are both important. For example,

Clue: This integer is the exponent of the number of miles in a light year.

Response: What is 12?

Clue: This integer is the exponent of the number of miles in a light second.

Response: What is 5?

Jeopardy! Game: Category: Physical Units

For our purposes we will be concerned about clues that involve physical quantities where the magnitude and units are both important. For example,

Clue: This U.S. Customary unit is used to describe the wing area of a Boeing 747 aircraft.

Response: What is feet squared?

Clue: This S.I. unit is used to describe the wing area of a Boeing 747 aircraft

Response: What is meter squared?

Clue: These S.I. units are used when describing the acceleration of gravity as having a magnitude of 9.81.

Response: What are meters per second squared.

Homework 6: Due Thursday, November 8, 2001

Each student must provide 10 clue-response (answer-question) pairs one each on a 3x5 inch card (or equivalent sized piece of paper). On one side of a 3x5 inch card put

the category (Power of Ten or Physical Units)
the clue (answer) first,
the response (question) second,
and on the last line your name and team number.

Write on only one side of the card. The clue-response pairs must involve physical quantities with magnitude and units. Please check your clue-response pairs for correctness. You may use either category "Power of Ten" or "Physical Units."

Clues should be in the form

This integer is the exponent of ...

Responses should be in the form

What is n ?

Or

This U.S. Customary unit ... (or This S.I. unit ...)

What is _____?

Basic Jeopardy! Rules (for the Television Show)

The game is played by three contestants in three rounds. In all rounds, money is earned by answering questions -- or in Jeopardy! parlance, by providing the questions to the answers. The wording is altered so that the "questions" are in answer format, and the contestants' "answers" must be in the form of a question. For simplicity, the terms "clues" and "responses" are usually used instead of "questions" and "answers".

While merely a gimmick, it is part of the game, and failure to respond in the form of a question can cost you money. (More on that later).

In the first round, there are six categories of five clues each, worth \$100 to \$500. The round is timed; play continues until all 30 clues are revealed, or time runs out. On each turn, the player in control first chooses a clue by announcing a category and dollar amount. (At game start, the player at the leftmost podium has control.) The clue is revealed on the TV monitor, read by the host, then (and only then) the contestants are allowed to ring in to answer. A correct response earns the value of the clue; an incorrect response subtracts the value of the clue from the player's total and gives the remaining contestants a chance to ring in. On a correct response, that player gains control and gets to select the next clue.

Also in the first round, there is one Daily Double hidden on the board behind one of the 30 clues. When a player hits the Daily Double, he/she is the only one with a chance to respond. The player announces a wager, then the clue is revealed as before. The player earns the amount of the wager on a correct response; otherwise (on a miss or no-answer), the value is deducted. The minimum wager is \$5, regardless of the player's score. The maximum wager is either all of the player's current score, or the maximum clue value in the round (in the first round, \$500), if the player has less than that value.

Most of the Daily Doubles are like regular clues, but some are "Audio Daily Doubles" or "Video Daily Doubles", which involve audio or video as part of the clue.

The second round (called Double Jeopardy!) plays much the same. Six new categories of five clues each are presented, this time worth \$200 to \$1000, and two Daily Doubles are hidden on the board. Play again continues until all clues are revealed, or time runs out.

The third round is called Final Jeopardy!. If a player has \$0 or a negative score at the end of Double Jeopardy!, that person is eliminated from the game and only the remaining players get to play Final Jeopardy! A single category is presented, and each player makes a wager in secret. Then the clue is revealed, and each player has 30 seconds to write down a response. Correct responses earn money, incorrect responses lose money. At the end of the game, the person with the most money wins the game.

During the first round, if the player forgets to use a question in his/her response, Alex will remind the player. During Double Jeopardy! and Final Jeopardy!, there are no reminders, and forgetting to do this is the same as a wrong response.

In regular season matches, only the champion gets to keep his/her money. The second and third place participants receive prizes, which are usually not too shabby. In all tournaments, losing contestants receive some cash award for participating. And in no case does a player with a negative score have to pay the show.