ENGINEERING VARIABLES

Engineers typically seek answers to such questions as “How hot will this get?,” “How heavy will it be?” Each of these questions involves a variable. The question “How hot?” is answered with the variable *temperature;* “How heavy?” is answered with the variable *weight.*

يجيب المهندسون بالأرقم عن أي تساؤل. كيف سيكون الطقس؟ يجيب المهندس: ستصل درجة الحراة إلى 40 درجة مئوية منتصف النهار....، بينما يجيب الآخرون سيكون الطقس حاراً. فالمهندس استخدم متحولاً وقد يعطينا رسماً بيانياً لتغير درجة الحرارة مع الوقت!!

For our purposes, variables almost always are defined in terms of measurements made with familiar instruments, such as thermometers, rulers, and clocks. Speed, for example, is defined as a ruler measurement of distance, divided by a clock measurement of time.

تستخدم في الهندسة أجهزة القياس المختلفة لتقدير كمي محدد لكل ما يتعلق بالمنتجات والتصاميم الهندسية.

An engineering calculation is different from a pure mathematical calculation. For example, 6.2832 is a legitimate answer to the mathematical question “What is the value of 2π ?” But, expressing something in numbers is only the beginning of an engineering calculation. In addition to variables based on measurements and expressed as numbers, we require a second key element of engineering analysis: **units of measurement.**

لكل رقم يستخدمه المهندس واحدة قياس.

ENGINEERING UNITS OF MEASUREMENT

لو كنت تقود سيارة مصنعة لتسير في أمريكا، لكن على طريق في أوروبا مر اقب بالرادار والسرعة القصوى مسجلة على لوحات الطريق 120، والتزمت بالأمر وقدت السيارة بسرعة 100 وفقا لمؤشر السرعة في لوحة القيادة أمامك، فستجد نفسك في ورطة مع شرطة المرور. لماذا؟

$$Speed[mile/h] = 1.61 Speed[km/h]$$

لو كنت مسافرا بالطائرة في زمن الكورونا وقيست حرارتك في مطار أمريكي و انت 90. هل ستستبعد من الرحلة؟

$$^{\circ}C = \frac{5}{9}(F - 32) \Leftrightarrow F = ??$$

In engineering, a calculated quantity always has two parts: the numerical value and its associated units. Therefore, the result of any engineering calculation must always be correct in two separate categories: It must have the **correct numerical value,** and it must have the **correct units.**

نتيجة أية حسابات هندسية يجب أن تحمل قيمة عددية دقيقة وواحدة قياس صحيحة.

Units quantify Dimensions.

Dimensions are the fundamental quantities, such as mass, length, and time.

Units provide us with a numerical scale whereby we can carry out a measurement of a quantity.

The units are established quite arbitrarily and are codified by civil law or cultural custom. How the dimension of length ends up being measured in units of feet or meters has nothing to do with any physical law. It is solely dependent on the creativity and ingenuity of people. Therefore, the basic tenets of units systems are often grounded in the complex roots of past civilizations and cultures.

الأبعاد هي الكميات الأساسية المعرفة لقوانين الفيزياء والمتوافقة معها. أما الواحدات فهي اصطلاحات معيارية لتمثيل الأبعاد الفيزيائية تتغير من بلد إلى آخر ومن وقت إلى آخر.

THE SI UNIT SYSTEM – نظام المقاييس أو الواحدات الدولي

The International System of Units (in French, Le Système International d'Unités, where the "SI" comes from) which is the metric standard of units and is based on mks (meter, kilogram, second) units. The fundamental units in the SI system are:

- The meter (m), the fundamental unit of length.
- The second (s), the fundamental unit of time.
- The kilogram (kg), the fundamental unit of mass.
- The degree kelvin (K), the fundamental unit of temperature.
- The mole (mol), the fundamental unit of quantity of particles.
- The ampere (A), the fundamental unit of electric current.

UNIT NAMES AND ABREVIATIONS

The next table lists several SI units that were named after the scientists who made discoveries in the fields in which these units are used. Note that these unit names do not begin with a capital letter, but their abbreviation is capitalized (e.g., newton, N).

SI units that were named after the scientists		
ampere (A)	**joule (J)**	**siemens (S)**
celsius (°C)	kelvin (K)	tesla (T)
coulomb (C)	newton (N)	volt (V)
farad (F)	ohm (Ω)	watt (W)
hertz (Hz)	pascal (Pa)	weber (Wb)

Rules in writing units ---- قواعد كتابة الوحدات

تبدأ أسماء الواحدات المشتقة من اسم علم أم لا، بحرف صغير إلا في بداية الجملة.

عندما يُكتب رمز الواحدة مختصرا، يبدأ بحرف كبير فقط إذا كان مشتقا من اسم علم.

أثناء إجراء بعض العمليات الحسابية إذا احتاج الأمر لذكر واحدة مقدار ما، نضع الواحدة بين معترضتين [...].

Some Derived SI Units.

Quantity	Name	Symbol	Formula	Fundamental Units
Frequency	hertz	Hz	1/s	s^{-1}
Force	newton	N	$kg\,m/s^2$	$m\,kg\,s^{-2}$
Energy	joule	J	N m	$m^2\,kg\,s^{-2}$
Power	watt	W	J/s	$m^2\,kg\,s^{-3}$
Electric charge	Coulomb	C	A s	A s
Electric potential	volt	V	W/A	$m^2\,kg\,s^{-3}\,A^{-1}$
Electric resistance	ohm	Ω	V/A	$m^2\,kg\,s^{-3}\,A^{-2}$
Electric capacitance	farad	F	C/V	$m^{-2}\,kg^{-1}\,s^4\,A^2$

SI Unit Prefixes.

Multiples	Prefixes	Symbols	Submultiples	Prefixes	Symbols
10^{18}	exa	E	10^{-1}	deci	D
10^{15}	peta	P	10^{-2}	centi	c
10^{12}	tera	T	10^{-3}	milli	m
10^{9}	giga	G	10^{-6}	micro	μ
10^{6}	mega	M	10^{-9}	nano	n
10^{3}	kilo	k	10^{-12}	pico	p
10^{2}	hecto	h	10^{-15}	femto	f
10^{1}	deka	da	10^{-18}	atto	a

SIGNIFICANT FIGURES --- الأرقام ذات الدلالة

تعطي الآلات الحاسبة نتائج العمليات الحسابية بعدد كبير من الأرقام (يمكن التحكم بذلك). يجب الاحتفاظ بعدد منها فقط، تكون له دلالة (أي معنى و اقعي أو فائدة) ويتناسب مع الهدف المراد من التصميم ومع الدقة التي يحتاجها تنفيذ هذا التصميم.

DEFINITION OF A SIGNIFICANT FIGURE

A significant figure is any one of the digits 1, 2, 3, 4, 5, 6, 7, 8, and 9. (0) is a significant except when it is used simply to fix the decimal.

Example: In 0.500 or 0.632000 the zeroes are significant, but in 0.006 or 0.000968 the zeroes are NOT significant.

The number 234 has three significant figures, and the number 7305 has four significant figures, since the zero within the number is a legitimate significant digit.

Leading zeroes before a decimal point are not significant. Thus, the number 0.000,452 has three significant figures (4, 5, and 2), the leading zeroes (including the first one before the decimal point) being place markers rather than significant figures.

Calculation Rules

Engineering calculations often deal with numbers having unequal numbers of significant figures. Several rules have been developed for various computations. These rules are the result of strict mathematical understanding of the propagation of errors due to arithmetical operations such as addition, subtraction, multiplication, and division.

RULE 1: ADDITION AND SUBTRACTION

يجب أن لا يحوي ناتج جمع أو طرح عددين، أرقاما ذات دلالة إلى يمين الفاصلة العشرية، أكثر مما هو معطى في العدد الأقل دقة بينهما.

For example, 113.2+1.43 = 114.63, must be rounded to 114.6.

Similarly, 113.2 – 1.43 = 111.77 must be rounded to 111.8.

And, 113.212–113.0 = 0.2

RULE 2: MULTIPLICATION AND DIVISION

يجب أن لا يحوي ناتج جداء أو قسمة عددين أرقاما ذات دلالة، أكثر من عدد أرقام الدلالة الأقل بينهما.

For example,(113.2)×(1.43)= 161.876, must be rounded to 162.

And, 113.2/1.43 = 79.16, must be rounded to 79.2

because 1.43 contains the least number of significant figures (i.e., three).

RULE 3: ROUNDING NUMBERS UP OR DOWN

For example, if to round 113.2 to three significant figures, it would be 113. If to round it further to two significant figures, it would be 110, and if to round it to one significant figure, it would be 100 with the trailing zeroes representing placeholders only.

As another example, 116.876 rounded to five significant figures is 116.88, which further rounded to four significant figures is 116.9, Which further rounded to three significant figures is 117.

EXAMPLES

a. The number of significant figures in 2.2900×10^{7}?	**is 5.**
b. The number of significant figures in 4.00×10^{-3} ?	**is 3.**
c. The number of significant figures in 480?	**is 2.**
d. The value of 345.678–345.912 =?	**= - 0.234**
e. The value of 345.678–345.9 =?	**=- 0.2.**

RULE 4: ONLY APPLY THE SIGNIFICANT FIGURES RULE TO YOUR FINAL ANSWER

For example, suppose you need to calculate the area of a circle and the answer is to be in square meter, but you are given the circle's radius as 22.5 cm. You can convert the radius into meter as R = 22.5[cm]/100 [cm/m] = 0.225 m. Then you would calculate the circle's area as

$A=\pi R^2=(3.1416)\times(0.225\ [m])^2=0.20428254\ m^2=0.204\ m^2$ (rounded to 3 significant figures)

A man wants to purchase the largest fenced-in square ranch he can afford. He has 320,000,000 SP available for the purchase. Fencing costs $10.\times10^6$ SP a kilometer, and land costs $100.\times10^6$ SP a square kilometer.

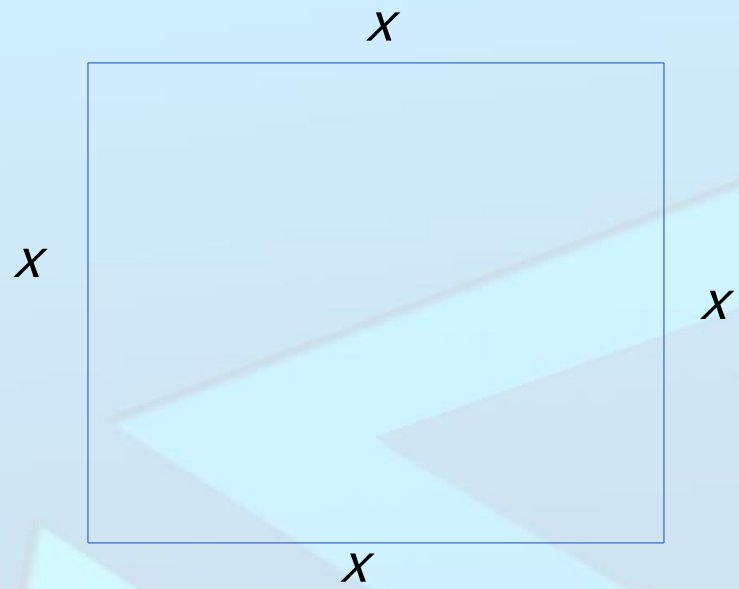
How large a ranch, as measured by the length of one side of the square, can he buy?

Need: The length of a side of the largest square of land the man can buy.

Knowns: Fencing costs $10.\times10^6$ SP a kilometer, and land costs $100.\times10^6$ SP square kilometer. The man has 320,000,000 SP to invest.

How?: Let the unknown length = X kilometers. It may not be immediately obvious how to write an equation to find X. Now sketch the ranch.

Solve:



مسألة تقديرات: كم محل للحلاقة الرجالية تحتاج مدينة عدد سكانها 60,000 نسمة؟ سجل فرضياتك المبررة لنتائجك.