Converting Units تحويل الوحدات

Suppose you are to convert 15 US Dollar ($) into Saudi Ryal (SR) :

1st Find conversion factor (معامل التحويل): 1 $ = 3.75 SR

2nd $\frac{1\$}{1\$} = \frac{3.75\,\text{SR}}{1\$} \Rightarrow 1 = 3.75\,\frac{\text{SR}}{\$}$

3rd $15\$ = 15\$ \times 1 = 15\$ \times 3.75\,\frac{\text{SR}}{\$} = 56.25\,\text{SR}$

Likewise convert 21.5 inches (in) into cm :

1st Conversion factor: 1 in = 2.54 cm

2nd $\frac{1\,\text{in}}{1\,\text{in}} = \frac{2.54\,\text{cm}}{1\,\text{in}} \Rightarrow 1 = 2.54\,\frac{\text{cm}}{\text{in}}$

3rd $21.5\,\text{in} = 21.5\,\text{in} \times 1 = 21.5\,\text{in} \times 2.54\,\frac{\text{cm}}{\text{in}} = 54.6\,\text{cm}$

Examples

Convert 23 cm into inches (1 in = 2.54 cm)

$$\frac{1\ \text{in}}{2.54\ \text{cm}} = 1$$

$$23\ \text{cm} \times 1 = 23\ \text{cm} \times \frac{1\ \text{in}}{2.54\ \text{cm}} = 9.1\ \text{in} \approx 9\ \text{in}$$

Convert 20 in into cm

$$\frac{1\ \text{in}}{1\ \text{in}} = \frac{2.54\ \text{cm}}{1\ \text{in}} \Rightarrow 1 = 2.54\ \frac{\text{cm}}{\text{in}}$$

$$20\ \text{in} \times 1 = 20\ \text{in} \times 2.54\ \frac{\text{cm}}{\text{in}} = 50.8\ \text{cm} \approx 50\ \text{cm}$$

Convert 120 km/h into m/s

$$\frac{1\ \text{km}}{1\ \text{km}} = \frac{1000\ \text{m}}{1\ \text{km}} \qquad \frac{1\ \text{h}}{3600\ \text{s}} = \frac{3600\ \text{s}}{3600\ \text{s}}$$

$$1 = 1000\ \frac{\text{m}}{\text{km}} \qquad \frac{1}{3600}\ \frac{\text{h}}{\text{s}} = 1$$

$$120\ \frac{\text{km}}{\text{h}} \times 1 \times 1 = 120\ \frac{\text{km}}{\text{h}} \times 1000\ \frac{\text{m}}{\text{km}} \times \frac{1}{3600}\ \frac{\text{h}}{\text{s}}$$

$$\approx 33.3\ \text{m/s}$$

EXAMPLE 1.4

Area of a semiconductor chip. A silicon chip has an area of 1.25 square inches. Express this in square centimeters.

$$1.25\ \text{in.}^2 = (1.25\ \text{in.}^2)\left(2.54\frac{\text{cm}}{\text{in.}}\right)^2 = (1.25\ \cancel{\text{in.}}^2)\left(6.45\frac{\text{cm}^2}{\cancel{\text{in.}}^2}\right) = 8.06\ \text{cm}^2.$$

EXAMPLE 1.5

Speeds. Where the posted speed limit is 55 miles per hour (mi/h or mph), what is this speed (*a*) in meters per second (m/s) and (*b*) in kilometers per hour (km/h)?

$$1\ \text{mi} = (5280\ \cancel{\text{ft}})\left(12\frac{\cancel{\text{in.}}}{\cancel{\text{ft}}}\right)\left(2.54\frac{\cancel{\text{cm}}}{\cancel{\text{in.}}}\right)\left(\frac{1\ \text{m}}{100\ \cancel{\text{cm}}}\right) = 1609\ \text{m}.$$

$$55\frac{\text{mi}}{\text{h}} = \left(55\frac{\cancel{\text{mi}}}{\cancel{\text{h}}}\right)\left(1609\frac{\text{m}}{\cancel{\text{mi}}}\right)\left(\frac{1\ \cancel{\text{h}}}{3600\ \text{s}}\right) = 25\frac{\text{m}}{\text{s}},$$

$$55\frac{\text{mi}}{\text{h}} = \left(55\frac{\cancel{\text{mi}}}{\text{h}}\right)\left(1.609\frac{\text{km}}{\cancel{\text{mi}}}\right) = 88\frac{\text{km}}{\text{h}}.$$

49. A distance of 10 ft. is equal to:

A	305 m
B	305 cm✓
C	30.5 cm
D	30.5 m

Hint:

1 ft = 12 in

and

1 in = 2.54 cm

52. The maximum capacity in liters of a 3-m^3 water tank (خزان) is:

A	30 L
B	3000 L✓
C	300 L
D	3 L

Hint:

1 m^3 = 1000 L

Order of Magnitude; Rapid Estimating
التقدير السريع لرُتبة ألقيمة

- Sometimes, we are interested in only an approximate (تقريب) value (مقدار أو قيمة) for a quantity (كمية). We are interested in obtaining rough (تقريبي او تقديري) or **order of magnitude estimates**.

- **Order of magnitude estimates**: Made by rounding (تقدير أو تقريب) off all numbers in a calculation to 1 significant figure, along with power of 10.
  - Can be accurate to within a factor of 10 (often better)

Order of Magnitude; Rapid Estimating
التقدير السريع لرُتبة ألقيمة

Steps for calculating the order of magnitude:

خطوات حساب رتبة القيمة لعدد معين

1. Express it in a scientific form (أُكتب العدد بالصيغة العلمية)
2. Round it to one significant figure (قرب لرقم نوعي واحد)
3. If the number is between 1 and 4, round it to 1. If the number is between 5 and 10 round it to 10

(إذا كان العدد من 1 الى 4 فقربه الى 1. وإذا كان بين 5 و 10 فقربه الى 10)

Example:

Determine the order of magnitude for 25633 m

1. $25633 = 2.5633 \times 10^4 \text{m}$
2. $2.5633 \times 10^4 \text{m} \approx 3 \times 10^4 \text{m}$
3. $3 \times 10^4 \text{m} \approx 1 \times 10^4 \text{m}$

So, 25633 m is ***of the order*** of $1 \times 10^4 \text{m}$ or 10^4m

أعلى 14 قمة (جبلية)

56. In the world, the 14 highest peaks are between 8000 m and 9000 m high. The order-of-magnitude of their height (ارتفاع) is:

A	1×10^4 m✓
B	0.1×10^4 m
C	2×10^4 m
D	10×10^4 m

Explanation:

$9000\ m \sim 10000\ m = 10^4\ m$

$\vdots$

$8500\ m \sim 9000\ m \sim 10000 = 10^4\ m$

$\vdots$

$8000 \sim 10000 = 10^4\ m$

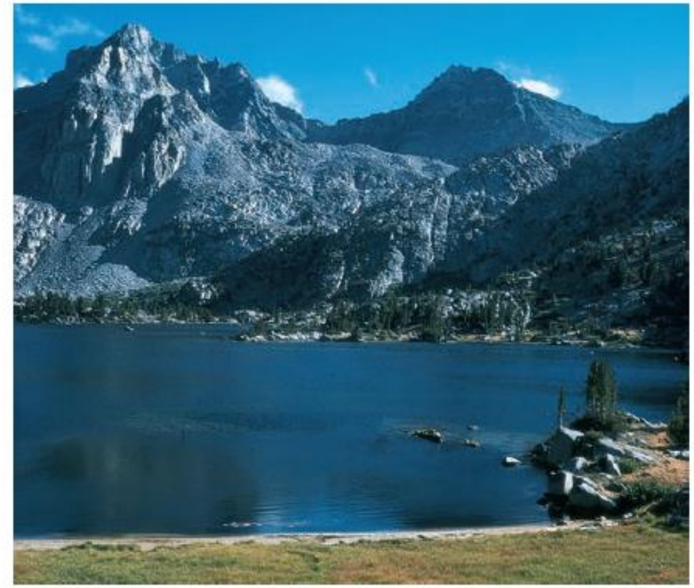
58. The thickness (سماكة) of a 200-page book is 1.0 cm. The thickness of one sheet of this book can be estimated as:

A	0.001 mm
B	0.01 mm
C	0.1 mm✓ $= 10^{-1}$ mm
D	1 mm

FIGURE 1.9
Example 1.7. A micrometer, which is used for measuring small thicknesses.

جهاز الميكروميتر البرغي ويستخدم لقياس سُمك صغير جدا.

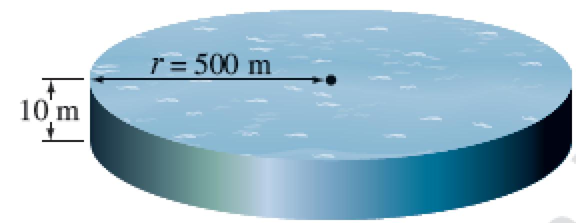
Volume of a lake. Estimate how much water there is in a particular lake, Figure 1.8a, which is roughly circular, about 1 km across, and you guess it has an average depth of about 10 m.



The volume V of a cylinder is the product of its height h times the area of its base: $V = h\pi r^2$, where r is the radius of the circular base. The radius r is $\frac{1}{2}$ km $=$ 500 m, so the volume is approximately

$$V = h\pi r^2 \approx (10\,\text{m}) \times (3) \times (5 \times 10^2\,\text{m})^2 \approx 8 \times 10^6\,\text{m}^3 \approx 10^7\,\text{m}^3,$$

where π was rounded off to 3. So the volume is on the order of $10^7\,\text{m}^3$, ten million cubic meters. Because of all the estimates that went into this calculation, the order-of-magnitude estimate ($10^7\,\text{m}^3$) is probably better to quote than the $8 \times 10^6\,\text{m}^3$



Total number of heartbeats. Estimate the total number of beats a typical human heart makes in a lifetime.

If an average person lives 70 years $\approx 2 \times 10^9$ s,

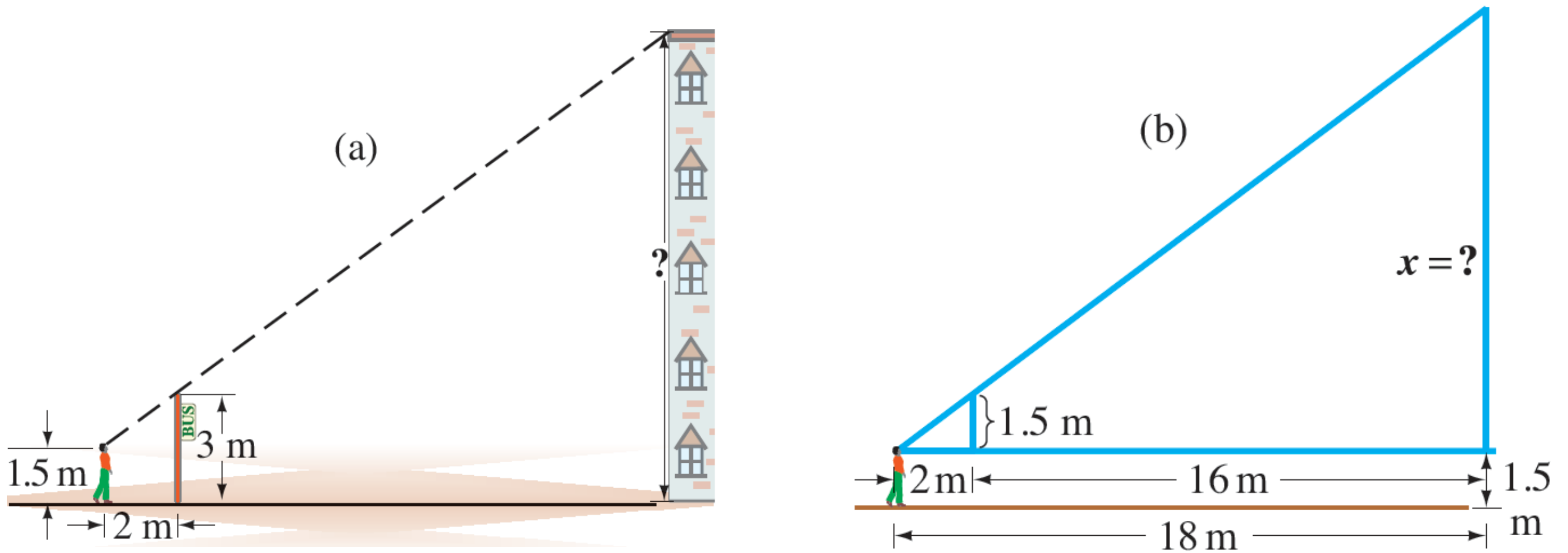
$$\left(80\,\frac{\text{beats}}{\text{min}}\right)\left(\frac{1\,\text{min}}{60\,\text{s}}\right)(2 \times 10^9\,\text{s}) \approx 3 \times 10^9,$$

or 3 trillion.

تقدير الارتفاع باستخدام قواعد المثلثات

Height by triangulation. Estimate the height of the building shown in Figure 1.10, by "triangulation," with the help of a bus-stop pole and a friend.

قُطب محطة الحافلة



Dimensions and Dimensional Analysis‡

ألابعاد و التحليل ألبعدي

The dimension of a physical quantity is the type of units or ***base quantities*** that make it up.

ألكمية ألاساسية **Base quantity**	إختصارات ألابعاد **Dimension abbreviation**
Length	**[L]**
Time	**[T]**
Mass	**[M]**
…	**…**

Dimension of the velocity & speed = $[V] = \frac{[L]}{[T]}$

Dimension of the acceleration = $\frac{[L]}{[T^2]}$

Dimensional analysis:

Example:

$$\underbrace{\underset{\text{Final velocity}}{V}}_{\text{Left Hand Side (LHS)}} = \underbrace{\underset{\text{Initial velocity}}{V} + \underset{\text{acceleration}}{a} \cdot \underset{\text{time}}{t^2}}_{\text{Right Hand Side (RHS)}}$$

$$\underset{\text{LHS dimension}}{\frac{[L]}{[T]}} \overset{?}{=} \underset{\text{RHS dimension}}{\frac{[L]}{[T]} + \frac{[L]}{[T^2]} \cdot [T^2]} = \underset{\text{RHS dimension}}{\frac{[L]}{[T]} + [L]}$$

$$\Rightarrow \text{LHS dimension} \neq \text{RHS dimension}$$

$\Rightarrow$ **The equation is *incorrect***

$$\text{If} \quad \text{LHS dimension} = \text{RHS dimension}$$

$\Rightarrow$ **The equation is *dimensionally correct***

(But could be physically incorrect)

60. The dimensions of volume are:

A	L^3✓
B	L^2
C	L^3/T^2
D	$L^2\ T^{-1}$

61. The dimensions of force are:

A	L M T
B	$L\ M\ T^{-2}$✓
C	$L^3\ M^2/T^2$
D	$L^2\ M\ T^{-1}$

62. * Which of the following is dimensionally correct?

A	speed = acceleration / time
B	distance = speed / time
C	force = mass × acceleration✓
D	density = mass × volume

Example: Which of the following is dimensionally correct (مما يلي أيهما صحيح الأبعاد)

$$T = 2\pi\sqrt{l/g} \text{ or } T = 2\pi\sqrt{g/l}$$

Where g is the acceleration due to gravity (تسارع الجاذبية الارضية)

$$T = 2\pi\sqrt{l/g}$$

$$[T] = \sqrt{\frac{[L]}{[L/T^2]}} = \sqrt{[T^2]} = [T]$$

صحيحة باعتبار الابعاد

$$T = 2\pi\sqrt{g/l}$$

$$[T] \stackrel{?}{=} \sqrt{\frac{[L/T^2]}{[L]}} \stackrel{?}{=} \sqrt{\frac{1}{[T^2]}} \stackrel{?}{=} \frac{1}{[T]}$$

غير صحيحة باعتبار الابعاد لان $[T] \neq \frac{1}{[T]}$

Simple calculators are allowed but are not crucial for this test. You may scribble your calculations on the sides and back of this test paper

You may need some of the following information

1 giga (G) = 10^9	1 mega (M) = 10^6	1 micro (μ) = 10^{-6}	1 nano (n) = 10^{-9}	1 liter = 1000 cm^3 1 m^3 = 10^6 cm^3
1 m/s = 3.6 km/h	1 in. = 2.54 cm	1 ft = 12 in.	1 yd = 3 ft	1 mi = 5280 ft = 1.6 km
Dimension of length: [L]	Dimension of time: [T]	Dimension of mass: [M]	speed = distance/time	$v_{final} = v_{initial} + a.t$; acceleration $a = \Delta v/t$

1. The percent uncertainty in the measurement 9.9 ± 0.1 cm is nearly:

A	2%
B	4%
C	3%
D	1%

2. The uncertainty in the measurement 9.23 cm is nearly:

A	0.10
B	0.01
C	0.30
D	0.20

3. Which of the following is not an SI base quantity:

A	length
B	speed
C	time
D	mass

4. Converting 10 *m/s* to k*m/h* gives:

A	36 km/h
B	18 km/h
C	10 km/h
D	72 km/h

5. In the measurement m = 4.02 g, the percent uncertainty is:

A	0.5 %
B	5 %
C	0.25 %
D	2.5 %

6. The number of significant figures in (0.1010) is:

A	3
B	2
C	1
D	4

Simple calculators are allowed but are not crucial for this test. You may scribble your calculations on the sides and back of this test paper

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Dimension of length: [L]	Dimension of time: [T]	Dimension of mass: [M]	speed = distance/time	$v_{final} = v_{initial} + a.t$; acceleration $a = \Delta v/t$

7. Taking accuracy into account, subtracting 0.57 from 3.6 gives:

A	3.1
B	0.57
C	3.0
D	3.03

8. 160 km is equivalent to:

A	256 miles
B	100 miles
C	16 miles
D	200 miles

9. Considering significant figures, the 15.0/3.0 is correctly written as:

A	5
B	5.0
C	5.00
D	5.000

10. The number of significant figures in 4.14×10^5 is:

A	2
B	3
C	1
D	4

11. The number 0.00321×10^5 can be expressed in scientific notation as:

A	3.21×10^5
B	3.21×10^{-3}
C	3.21×10^2
D	3.21×10^4

12. Taking significant figures into account, (6.5×1.25) is correctly written as:

A	**8.1**
B	**8.13**
C	**8**
D	**8.125**

Simple calculators are allowed but are not crucial for this test. You may scribble your calculations on the sides and back of this test paper

You may need some of the following information

1 giga (G) = 10^9	1 mega (M) = 10^6	1 micro (μ) = 10^{-6}	1 nano (n) = 10^{-9}	1 liter = 1000 cm^3 1 m^3 = 10^6 cm^3
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Dimension of length: [L]	Dimension of time: [T]	Dimension of mass: [M]	speed = distance/time	$v_{final} = v_{initial} + a.t$; acceleration $a = \Delta v/t$

13. The order-of-magnitude of the number (9380) is:

A	10^5
B	10^3
C	10^6
D	10^4

14. The number 1.234×10^3 km can be written as:

A	1.234 km
B	1234 Mm
C	1.234 Mm
D	12.34 km

15. Of the following, the SI base quantity is:

A	mass
B	speed
C	acceleration
D	force

16. The SI unit of length is the:

A	inch
B	yard
C	mile
D	meter

17. **The density of water is 1000 kg/m^3. This is equivalent to:**

A	**0.1 g/cm^3**
B	**10 g/cm^3**
C	**1 gram/cm^3**
D	**0.01 g/cm^3**

18. The dimension of (distance × speed) is:

A	$[L\,T^3]$
B	$[L^3 / T^2]$
C	$[L^3\,T]$
D	$[L^2 T^{-1}]$

19. The dimension of (distance × speed/area) is:

A	$[T^{-1}]$
B	[T]
C	[L/T]
D	[LT]

20. The equation: *area* = *k*.*l* is dimensionally correct if the dimension of *k* is: (*l* is a length)

A	L
B	L^{-2}
C	L^2
D	L^{-1}

END OF CHAPTER ONE