

# Physics 101 P

## General Physics I

Problem Sessions - Week 1

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## General Info

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& by appointment

& open door policy

Website

[ajackura.github.io/courses/phys101p-fall-2023.html](https://ajackura.github.io/courses/phys101p-fall-2023.html)

## Participation

Be engaged!

- Show up to discussions
- Ask questions to instructor
- Answer questions from instructor
- Talk w/ neighbors about physics

⇒ 2% Engagement bonus

## Problem Solving in Physics

Solving physics problems often requires using different fields of mathematics (e.g., algebra, trigonometry, calculus) as well physical intuition from our every day experiences.

Our goal in these discussions is to complement the lectures by applying physics concepts to exercises.

## Dimensions & Units

Physical quantities have two features

Dimensions - basic nature of physical quantity

e.g., Time

Units - system of measurement for physical quantity

e.g., seconds

Three fundamental dimensions

- Time ( $T$ )
- Length ( $L$ )
- Mass ( $M$ )

## Notation

For any physical quantity  $Q$ ,  
the dimension of  $Q$  is denoted  $[Q]$

e.g.,  $[Distance] = L$

$[Speed] = L/T$

$[Density] = M/L^3$

SI units       $\text{Système International}$   
d' unités

Each dimension has an associate unit

Time - second (s)

Length - meter (m)

Mass - kilogram (kg)

## Unit Prefixes

useful for working w/ large / small numbers

Tetra -  $\times 10^{12}$  T

Giga -  $\times 10^9$  G

Mega -  $\times 10^6$  M

Kilo -  $\times 10^3$  k

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centi -  $\times 10^{-2}$  c

milli -  $\times 10^{-3}$  m

micro -  $\times 10^{-6}$  μ

nano -  $\times 10^{-9}$  n

pico -  $\times 10^{-12}$  p

femto -  $\times 10^{-15}$  f

Any physical quantity can be multiplied by 1 without changing its value.

e.g.,  $1 \text{ min} = 60 \text{ s}$

$$\Rightarrow 1 = \frac{60 \text{ s}}{1 \text{ min}}$$

$1 \text{ ft} = 12 \text{ in.}$

$$\Rightarrow 1 = \frac{1 \text{ ft}}{12 \text{ in.}}$$

## Example

Alice is driving at 55 mi/hr

What is her speed in meters per second?

## Solution

Conversion factors:

$$1 \text{ mi} = 1609 \text{ m} \Rightarrow 1 = \frac{1609 \text{ m}}{1 \text{ mi}}$$

$$1 \text{ hr} = 3600 \text{ s} \Rightarrow 1 = \frac{1 \text{ hr}}{3600 \text{ s}}$$

$$\begin{aligned} \text{Speed} &= 55 \frac{\text{mi}}{\text{hr}} && \begin{array}{l} \text{mi to m} \\ \swarrow \\ \end{array} && \begin{array}{l} \text{hr to s} \\ \searrow \\ \end{array} \\ &= 55 \frac{\text{mi}}{\text{hr}} \cdot 1 \cdot 1 \\ &= 55 \cancel{\frac{\text{mi}}{\text{hr}}} \cdot \left( \frac{1609 \text{ m}}{1 \text{ mi}} \right) \cdot \left( \frac{1 \cancel{\text{hr}}}{3600 \text{ s}} \right) \end{aligned}$$

$$\text{Speed} = \frac{55 \cdot 1609}{3600} \frac{\text{m}}{\text{s}}$$

$$= 24.587944\ldots \frac{\text{m}}{\text{s}}$$



Not all these digits are meaningful. Started w/ 2 sig. figs. ( $55 \text{ mi/hr}$ ) so, let's report 2 sig. figs.

$$\Rightarrow \boxed{\text{Speed} = 25 \frac{\text{m}}{\text{s}}}$$

N.B. Speed of light  $\sim 3 \times 10^8 \frac{\text{m}}{\text{s}}$  !

## Example

Alice is 22 y old. How many seconds has she lived?



Alice

## Solution

$$\text{Let } T = \text{Alice's age}$$

$$= 22 \text{ y}$$

Conversion factors:

$$1 \text{ y} = 365 \text{ d} \Rightarrow 1 = \frac{365 \text{ d}}{1 \text{ y}}$$

$$1 \text{ d} = 24 \text{ hr} \Rightarrow 1 = \frac{24 \text{ hr}}{1 \text{ d}}$$

$$1 \text{ hr} = 3600 \text{ s} \Rightarrow 1 = \frac{3600 \text{ s}}{1 \text{ hr}}$$

So,

$$T = 22 \text{ y} \cdot 1 \cdot \frac{\text{y} + \text{d}}{1} \cdot \frac{\text{d} + \text{hr}}{1} \cdot \frac{\text{hr} + \text{s}}{1}$$

$$= 22 \text{ y} \cdot 1 \cdot 1 \cdot 1 \cdot 1$$

$$T = 22 \cancel{y} \cdot \left( \frac{365 \cancel{d}}{1 \cancel{y}} \right) \cdot \left( \frac{24 \cancel{h}}{1 \cancel{d}} \right) \cdot \left( \frac{3600 \cancel{s}}{1 \cancel{h}} \right)$$

$$= (22 \cdot 365 \cdot 24 \cdot 3600) s$$

$$= 6.93792 \dots \times 10^8 s$$

$\nearrow$   
 $22 \cancel{y} \Rightarrow 2 \text{ cij. fijss.}$

$\Rightarrow$

$$T = 6.9 \times 10^8 s$$

N.B. Age of universe  $\sim 5 \times 10^{17} s$  !

## Example

Bob's car holds 16 gallons of gas. What is the tank volume in cubic centimeters?

## Solution

Let's say we know  $1 \text{ gal} = 231 \text{ in.}^3$ .

We also know  $2.54 \text{ cm} = 1 \text{ in.}$

So, we have

$$\begin{aligned}
 \text{Volume} &= 16 \text{ gal} \\
 &= 16 \text{ gal} \cdot 1 \cdot 1 \\
 &= 16 \text{ gal} \cdot \left( \frac{231 \text{ in.}^3}{1 \text{ gal}} \right) \cdot \left( \frac{2.54 \text{ cm}}{1 \text{ in.}} \right)^3 \\
 &= (16 \cdot 231 \cdot (2.54)^3) \text{ cm}^3 \\
 &= 60566.588\ldots \text{ cm}^3
 \end{aligned}$$

Need to insert  
 3 copies  
 & conversion

$\text{gal} + \text{in.}^3$   
 $\text{in.}^3 + \text{cm}^3$

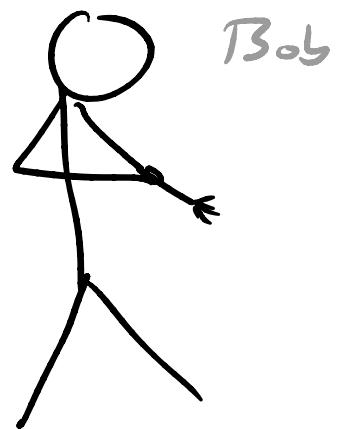
$\text{cm}$   
 and, 2 sig. figs

$\text{volume} = 6.1 \times 10^4 \text{ cm}^3$

## Example

Bob's resting heart rate is 71.5 beats/min.

How many times does Bob's heart beat in a day?



## Solution

Let  $R =$  Bob's heart rate

$$= 71.5 \text{ beats/min.}$$

The number of beats is then

$$N = R \cdot T$$

↑              ↑  
 heart rate      total time

$$T = 1 \text{ day} = 1 \cancel{\text{day}} \cdot \left( \frac{24 \text{ hr}}{1 \cancel{\text{day}}} \right) \cdot \left( \frac{60 \text{ min}}{1 \cancel{\text{hr}}} \right)$$

$$= 24 \cdot 60 \text{ min}$$

$$= 1440 \text{ min}$$

So,

$$N = R \cdot T$$

$$= \left( 71.5 \frac{\text{bcs}}{\text{min}} \right) \cdot (1440 \text{ min})$$

$$= (71.5 \cdot 1440) \text{ bcs}$$

$$= 102960 \text{ bcs}$$

↗ 3 sig. figs. from 71.5

$\Rightarrow$

$$N = 1.03 \times 10^5 \text{ bcs}$$

## Example

Alice wants to calculate the area of an 8.5 in.  $\times$  11 in. piece of paper.

What is the area in  $\text{cm}^2$ ?

## Solution

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

$$\text{Let } L = \text{length} = 11 \text{ in.}$$

$$W = \text{width} = 8.5 \text{ in.}$$

$$\Rightarrow L = 11 \text{ in.} \cdot \left( \frac{2.54 \text{ cm}}{1 \text{ in.}} \right)$$

$$= 27.9 \text{ cm}$$

$$W = 8.5 \text{ in.} \cdot \left( \frac{2.54 \text{ cm}}{1 \text{ in.}} \right)$$

$$= 21.6 \text{ cm}$$

Area of a rectangle

$$A = L \cdot W$$

So,  $A = L \cdot W$

$$= (27.9 \text{ cm}) \cdot (21.6 \text{ cm})$$

$$= 602.64 \text{ cm}^2$$

round ↑  
to 3 sig. figs.

$\Rightarrow$

$$A = 603 \text{ cm}^2$$

## Example

Bob wants to measure the thickness

of an 8.5 cm x 11 cm piece of paper.

Bob measures 80 sheets and finds 1.27 cm.

What is the thickness?

## Solution

$$\text{Let } D = \text{thickness of 80 sheets}$$
$$= 1.27 \text{ cm}$$

$$\text{Let } d = \text{thickness of single sheet.}$$

$$N = \text{Number of sheets} = 80$$

$$\text{So, } D = N \cdot d \Rightarrow d = \frac{D}{N}$$

$$d = \frac{1.27 \text{ cm}}{80} = 0.015875 \text{ cm}$$

↗ 3 sig. figs  
(N.B. not 2  
since 80 is  
exact!)

$$\Rightarrow d = 0.159 \text{ mm}$$