Your Survival manual for PHYS 111. The Checklist:
(12-14 hours a week is expected in order to understand 18 chapters in 16 weeks.)

- Read the text before each lecture,
  otherwise lectures will definitely be too quick and too hard for you.
- Understand all concepts, equations and “why” in lectures.
  You will get lost if you just memorize facts or plug numbers.
- Don’t miss class. To make-up takes 3 times of lecture time
  Carefully review notes if you have an unavoidable absence.
- Study in groups and help each other, but do not simply give or ask for answers.
- Do homework independently after discussions. Allow enough time.
  Make sure that you understand everything by yourself. Mark those hard ones.
- Request keys on webassign.
  Review HW solutions posted on course website after due date.
  Redo all the hard ones before quizzes and exams.
- Go to at least one help session every week.
  PHYS 111 lectures are not long enough for showing many step by step examples.
- Improve your math skills.
  Otherwise, you will have a hard time solving equations for physical quantities.
- Keep up with the materials as it is covered.
  New sessions build on the previous. It is much harder to catch up once fall behind

The most important thing is to reserve fixed period of time every week for each tasks

Please fill the blanks with reserved time slots for PHYS 111.
(2 to 3 times per week, 0.5-4 hours per event as suggested below)

Example:
Reading text before lectures: (1-3hr)
  _Sun 8-10PM________Tue 6-7 PM_________Thur6-7 PM___
Review Lecture notes:(0.5-1 hr)
  _Mon 5-5:30PM_______Wed 6-7 PM_________Fri6-7 PM___
Do HW:(1-4 hrs)
  _Mon 6-8PM______Wed 7-9 PM________Sat1-4 PM___
Review HW solutions:(0.5-2 hrs)
  _Sat12-1 PM________Sun 9-10 AM_____
Attend SCI 111, help session or office hours:___F 12-1PM_____
Units of Chapter 1

- Physics and the Laws of Nature
- Units of Length, Mass, and Time
- Dimensional Analysis
- Significant Figures
- Converting Units
- Order-of-Magnitude Calculations
- Scalars and Vectors
- Problem Solving in Physics

1-1 Physics and the Laws of Nature

Physics: the study of the fundamental laws of nature
- these laws can be expressed as mathematical equations
- much complexity can arise from relatively simple laws
### 1-2 Units of Length, Mass, and Time

#### TABLE 1-1 Typical Distances

<table>
<thead>
<tr>
<th>Distance</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from Earth to the nearest large galaxy (the Andromeda galaxy, M31)</td>
<td>$2 \times 10^{22}$ m</td>
</tr>
<tr>
<td>Diameter of our galaxy (the Milky Way)</td>
<td>$8 \times 10^{20}$ m</td>
</tr>
<tr>
<td>Distance from Earth to the nearest star (other than the sun)</td>
<td>$4 \times 10^{16}$ m</td>
</tr>
<tr>
<td>One light year</td>
<td>$9.46 \times 10^{15}$ m</td>
</tr>
<tr>
<td>Average radius of Pluto’s orbit</td>
<td>$6 \times 10^{12}$ m</td>
</tr>
<tr>
<td>Distance from Earth to the Sun</td>
<td>$1.5 \times 10^{11}$ m</td>
</tr>
<tr>
<td>Radius of Earth</td>
<td>$6.37 \times 10^{6}$ m</td>
</tr>
<tr>
<td>Length of a football field</td>
<td>$10^2$ m</td>
</tr>
<tr>
<td>Height of a person</td>
<td>$2$ m</td>
</tr>
<tr>
<td>Diameter of a CD</td>
<td>$0.12$ m</td>
</tr>
<tr>
<td>Diameter of the aorta</td>
<td>$0.018$ m</td>
</tr>
<tr>
<td>Diameter of a period in a sentence</td>
<td>$5 \times 10^{-4}$ m</td>
</tr>
<tr>
<td>Diameter of a red blood cell</td>
<td>$8 \times 10^{-6}$ m</td>
</tr>
<tr>
<td>Diameter of the hydrogen atom</td>
<td>$10^{-10}$ m</td>
</tr>
<tr>
<td>Diameter of a proton</td>
<td>$2 \times 10^{-15}$ m</td>
</tr>
</tbody>
</table>

Human hair diameter
~ 0.1 mm
~ $10^{-4}$ meter
~ 100 micron

#### TABLE 1-2 Typical Masses

<table>
<thead>
<tr>
<th>Mass</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Galaxy (Milky Way)</td>
<td>$4 \times 10^{41}$ kg</td>
</tr>
<tr>
<td>Sun</td>
<td>$2 \times 10^{30}$ kg</td>
</tr>
<tr>
<td>Earth</td>
<td>$5.97 \times 10^{24}$ kg</td>
</tr>
<tr>
<td>Space shuttle</td>
<td>$2 \times 10^{6}$ kg</td>
</tr>
<tr>
<td>Elephant</td>
<td>5400 kg</td>
</tr>
<tr>
<td>Automobile</td>
<td>1200 kg</td>
</tr>
<tr>
<td>Human</td>
<td>70 kg</td>
</tr>
<tr>
<td>Baseball</td>
<td>0.15 kg</td>
</tr>
<tr>
<td>Honeybee</td>
<td>$1.5 \times 10^{-4}$ kg</td>
</tr>
<tr>
<td>Red blood cell</td>
<td>$10^{-13}$ kg</td>
</tr>
<tr>
<td>Bacterium</td>
<td>$10^{-15}$ kg</td>
</tr>
<tr>
<td>Hydrogen atom</td>
<td>$1.67 \times 10^{-27}$ kg</td>
</tr>
<tr>
<td>Electron</td>
<td>$9.11 \times 10^{-31}$ kg</td>
</tr>
</tbody>
</table>

1kg ~

1 liter of water
(10 cm by 10 cm by 10 cm)

7 baseballs

¼ gallon milk

½ box of juice

4 cups of water

2.2 pound
1-2 Units of Length, Mass, and Time

**TABLE 1–3 Typical Times**

<table>
<thead>
<tr>
<th>Human reaction time</th>
<th>0.8 s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human hair diameter</td>
<td>~ 0.1 mm</td>
</tr>
<tr>
<td>One cycle of a high-pitched sound wave</td>
<td>~ 10^{-5} s</td>
</tr>
<tr>
<td>One cycle of an AM radio wave</td>
<td>10^{-6} s</td>
</tr>
<tr>
<td>One cycle of a visible light wave</td>
<td>2 × 10^{-15} s</td>
</tr>
</tbody>
</table>

1 second is roughly Equal to the time to say:

One thousand

or

One Mississippi

**TABLE 1–4 Common Prefixes**

<table>
<thead>
<tr>
<th>Power</th>
<th>Prefix</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>10^{15}</td>
<td>peta</td>
<td>P</td>
</tr>
<tr>
<td>10^{12}</td>
<td>tera</td>
<td>T</td>
</tr>
<tr>
<td>10^{9}</td>
<td>giga</td>
<td>G</td>
</tr>
<tr>
<td>10^{6}</td>
<td>mega</td>
<td>M</td>
</tr>
<tr>
<td>10^{3}</td>
<td>kilo</td>
<td>k</td>
</tr>
<tr>
<td>10^{2}</td>
<td>hecto</td>
<td>h</td>
</tr>
<tr>
<td>10^{1}</td>
<td>deka</td>
<td>da</td>
</tr>
<tr>
<td>10^{-1}</td>
<td>deci</td>
<td>d</td>
</tr>
<tr>
<td>10^{-2}</td>
<td>centi</td>
<td>c</td>
</tr>
<tr>
<td>10^{-3}</td>
<td>milli</td>
<td>m</td>
</tr>
<tr>
<td>10^{-6}</td>
<td>micro</td>
<td>μ</td>
</tr>
<tr>
<td>10^{-9}</td>
<td>nano</td>
<td>n</td>
</tr>
<tr>
<td>10^{-12}</td>
<td>pico</td>
<td>p</td>
</tr>
<tr>
<td>10^{-15}</td>
<td>femto</td>
<td>f</td>
</tr>
</tbody>
</table>

Human hair diameter

~ 0.1 mm

~ 10^{-4} meter

~ 100 micron , 100 μm
1-2 SI Units of Length, Mass, and Time

• Length: the meter
• Was: one ten-millionth of the distance from the North Pole to the equator
• Now: the distance traveled by light in a vacuum in 1/299,792,458 of a second

• Mass: the kilogram
• One kilogram is the mass of a particular platinum-iridium cylinder kept at the International Bureau of Weights and Standards, Sèvres, France.

• Time: the second
• One second is the time for radiation from a cesium-133 atom to complete 9,192,631,770 oscillation cycles.

It is a good habit to convert to all values into SI unit, before plugging numbers into equations.

1-5 Converting Units

Converting feet to meters:

\[ 1 \text{ m} = 3.281 \text{ ft} \] (this is a conversion factor)

\[ 1 = 1 \text{ m} / 3.281 \text{ ft} \]

\[ 316 \text{ ft} \times (1 \text{ m} / 3.281 \text{ ft}) = 96.3 \text{ m} \]

Always multiply something equals to one.
This is the key to use the conversion factor correctly!

Note that the units cancel properly –

\[ \text{Question 2} \quad 20 \text{ mile/hour} = \frac{\text{m}}{\text{s}} \]

\[ \frac{\text{mile}}{\text{hour}} \times \frac{\text{hour}}{3600 \text{ s}} \times \frac{1600 \text{ m}}{1 \text{ mile}} = \frac{20}{3600} \times 1600 \frac{\text{m}}{\text{s}} = 8.9(\text{m/s}) \]
One 10-inch pizza is as big as how many 5-inch pizza?

\[(ab)^2 = a^2b^2\]
\[(2b)^2 = 4b^2\]
\[(10 \text{ mm})^2 = 10^2 \text{ mm}^2\]
\[(10 \text{ cm})^3 = 10^3 \text{ cm}^3\]

One 10-inch pizza is as big as FOUR 5-inch pizza?

**Be very careful when unit involve square. Cubic. etc**

- \[1 \text{ cm} = 10 \text{ mm}\]
- \[1 \text{ cm}^2 = 10 \times 10 \text{ mm}^2\]
- \[1 \text{ m} = 100 \text{ cm}\]
- \[1 \text{ m}^3 = 10^6 \text{ cm}^3\]
- \[1 \text{ ft} = 12 \text{ inch}\.\]
- \[1 \text{ ft}^2 = 144 \text{ inch}^2\.

**It is a good habit to convert to all values into SI unit, before plugging numbers into equations.** Because if all numbers used are in SI unit, through a complicated calculation you will always get the answer in its SI unit.

Follow this example yourself to find the density of an object which is 8500g and 5000 cm³. Density = mass/ volume

(Its density is 1.7g/cm³, how many kg/m³?) It's easier to find mass and volume in SI unit first.

\[
1 \text{ m} = 100 \text{ cm}, \quad 1 \text{ m}^3 = 100^3 \text{ cm}^3 = 10^6 \text{ cm}^3
\]
\[
8500 g = 8500 g \times \frac{1 \text{ kg}}{1000 g} = 8.500 \text{ kg},
\]
\[
5000 \text{ cm}^3 = 5000 \text{ cm}^3 \times \frac{1 \text{ m}}{100 \text{ cm}} \times \frac{1 \text{ m}}{100 \text{ cm}} \times \frac{1 \text{ m}}{100 \text{ cm}}
\]
\[
= \frac{5000 \text{ m}^3}{100 \times 100 \times 100} = 5 \times 10^{-3} \text{ m}^3
\]
\[
density = \frac{8.5 \text{ kg}}{5 \times 10^{-3} \text{ m}^3} = 1.7 \times 10^3 \left(\frac{\text{kg}}{\text{m}^3}\right)
\]
1-3 Dimensional Analysis

15 years+ 1.5 meter doesn’t make sense.

- Any valid physical formula must be dimensionally consistent – each term must have the same dimensions

| TABLE 1–5 Dimensions of Some Common Physical Quantities |
|----------------|----------------|
| Quantity       | Dimension      |
| Distance       | [L]            |
| Area           | [L^2]          |
| Volume         | [L^3]          |
| Velocity       | [L]/[T]        |
| Acceleration   | [L]/[T^2]      |
| Energy         | [M][L^2]/[T^2] |

- From the table:
- Distance = velocity \times time
- Velocity = acceleration \times time
- Energy = mass \times (velocity)^2

Most other physics variables come from these three basic dimensions:

- Time [t] second
- Mass [m] kg
- Length [L] meter

Different dimension may multiply or divide but cannot be added or subtracted.

Check and make sure all items in your equation have SAME DIMENSION.

- \frac{\text{Mass}}{\text{Volume}} = \frac{\text{Mass}}{\text{length} \times \text{length} \times \text{length}}
- \text{volume density} = \frac{\text{Mass}}{\text{LxHxW}}
- \text{Energy} = \text{Force} \times \text{length}
- \text{acceleration} = \frac{\text{velocity}}{\text{time}}
- \text{speed} = \frac{\text{length}}{\text{time}}

Looks right.

- \text{Energy} + \text{force} must be wrong!
- \text{acceleration} + \text{velocity} must be wrong!
- \text{speed} + \text{length} must be wrong!

Speed \times \text{time} + \text{length} = \text{some other length}, could be correct.
1-4 Significant Figures

• Round-off error:
  • The last digit in a calculated number may vary depending on how it is calculated, due to rounding off of insignificant digits
  • Example: Two objects at price of $2.21 and $1.35
  • $2.21 plus 8% tax = $2.3868, rounds to $2.39
  • $1.35 plus 8% tax = $1.458, rounds to $1.46
  • Sum: $2.39 + $1.46 = $3.85
  • $2.21 plus $1.35 = $3.56
  • $3.56 + 8% tax = $3.84

Significant figures

After calculation, find result's number of SF should match with that of given values.

Significant figures are number of digits reliably known.

Count from left to right, start with the first non-zero digit. All the way to the right. Calculation the ending zeros on the right, unless the number is an integer and has no decimal point.

2.10 mm (3 SF) 2.1 mm (2 SF),
0.00210 mm (3 SF) 0.0021 m (2 SF),
6 × 10^3 seconds (1 SF) 6000 seconds (1 SF),
6.001 × 10^3 seconds (4 SF) 6000. seconds (4 SF),
6.000 × 10^3 seconds (4 SF),
webassign accept answers within 1% of error, 0.991,1.005

For webassign homework, if you keep 3-4 digits of SF, you can avoid round-off error with webassign. For experiments data and calculation. Number of significant figures should be determined by the experiment uncertainty.
1-4 Significant Figures

- accuracy of measurements is limited
- significant figures: the number of digits in a quantity that are known with certainty
- number of significant figures after multiplication or division is the number of significant figures in the least-known quantity

(Some constant number like a factor or 2, 24 hrs per day, 60 seconds per minute, do not have uncertainty and they DO NOT the number of significant figures of the results)

2.36 minute = 2.36 x 60 seconds = 141.6 seconds
Round off to 142 seconds, 3 significant digits

1-6 Order-of-Magnitude Calculations

Why are estimates useful?
1. as a check for a detailed calculation — if your answer is very different from your estimate, you’ve probably made an error
2. to estimate numbers where a precise calculation cannot be done

Order-of-Magnitude Calculation:
Example: Amount of Human hair

Area covered with hair is roughly a half sphere of radius 10 cm: 
\[ 0.5 \times (4 \pi r^2) = 2 \times 3.14 \times 10^2 \text{, roughly } 600 \text{(cm)}^2 = 60000 \text{ mm}^2 = 6 \times 10^4 \text{ mm}^2. \]

There is about 1 hair per mm^2:

Total Number of hair is about \( 6 \times 10^4 \)

Order of magnitude: \( 10^4 \sim 10^5 \), not \( 10^6 \).
Pigeon-hole Principle (Drawer theory):
If number of pigeons > number of holes, at least two Pigeon would stay in the same hole.

If $N_a > N_b$, at least two “A”, will share one “B”.

Example: If the number of people is 368, which is > 366 (possible # of different birthdays), At least two of them will share birthday.

Possible hair numbers: 1 to $10^5$, (no more than $10^6$)
# of people in SFSU: $3 \times 10^4$ (not sure)
# of people in NYC: $8 \times 10^6$ (many of them must share hair numbers)

1-7 Scalars and Vectors

Scalar – a numerical value.
May be positive or negative.
Examples: temperature, speed, height

Vector – a quantity with both magnitude and direction.
Examples: displacement (e.g., 10 feet north), force, magnetic field.
1-8 Problem Solving in Physics

No recipe or plug-and-chug works all the time, but here are some guidelines:
1. Read the problem carefully
2. Sketch the system
3. Visualize the physical process
4. Strategize
5. Identify appropriate equations
6. Solve the equations
7. Check your answer
8. Explore limits and special cases

Summary of Chapter 1

• Physics is important and fun!
• To learn Physics is not easy. WORK HARD!
• Units of length are meters; of mass, kilograms; and of time, seconds
• All terms in an equation must have the same dimensions
• The number of significant figures of a calculation is limited by the least accurate measurement used in it.
Summary of Chapter 1

• Convert one unit to another by something equals to 1. For example: (1 hour/60 minutes)
• Order-of-magnitude calculations are designed to be accurate within a power of 10
• Scalars are numbers; vectors have both magnitude and direction
• Problem solving: read, sketch, visualize, strategize, identify equations, solve, check, explore limits