DEVIL PHYSICS
THE BADDEST CLASS ON CAMPUS
IB PHYSICS

TSOKOS LESSON 1-1
MEASUREMENTS IN PHYSICS

Questions from Reading Activity?

Essential Idea

- Since 1948, the Système International d'Unités (SI) has been used as the preferred language of science and technology across the globe and reflects current best measurement practice.

Nature Of Science

- Common terminology: Since the 18th century, scientists have sought to establish common systems of measurements to facilitate international collaboration across science disciplines and ensure replication and comparability of experimental findings. (1.6)
- Improvement in instrumentation: An improvement in apparatus and instrumentation, such as using the transition of cesium-133 atoms for atomic clocks, has led to more refined definitions of standard units. (1.8)
- Certainty: Although scientists are perceived as working towards finding “exact” answers, the unavoidable uncertainty in any measurement always exists. (3.6)

International-Mindedness

- Scientific collaboration is able to be truly global without the restrictions of national borders or language due to the agreed standards for data representation.

Theory Of Knowledge

- What has influenced the common language used in science?
- To what extent does having a common standard approach to measurement facilitate the sharing of knowledge in physics?

Understandings

- Fundamental and derived SI units
- Scientific notation and metric multipliers
- Significant figures
- Orders of magnitude
- Estimation

Applications And Skills

- Using SI units in the correct format for all required measurements, final answers to calculations and presentation of raw and processed data
- Using scientific notation and metric multipliers
- Quoting and comparing ratios, values and approximations to the nearest order of magnitude
- Estimating quantities to an appropriate number of significant figures

Data Booklet Reference

- Metric (SI) multipliers can be found on page 5 of the physics data booklet

Orders of Magnitude

- Physics deals with stuff that is really small and stuff that is really big
  - The mass of an electron is about 10^{-30} kg
  - The mass of the universe is about 10^{53} kg
- Consider the relative size of objects in the universe
  - Planets
- IB Physics will use scientific notation much more than Pre-IB

Orders of Magnitude

Powers of ten – Scales of the Universe

Orders of Magnitude - Length

	Length/m
Distance to edge of observable universe	10^{26}
Distance to the Andromeda galaxy	10^{22}
Diameter of the Milky Way galaxy	10^{21}
Distance to nearest star	10^{16}
Diameter of solar system	10^{13}
Distance to sun	10^{11}
Radius of the earth	10^{7}
Size of a cell	10^{-5}
Size of a hydrogen atom	10^{-10}
Size of a nucleus	10^{-15}
Size of a proton	10^{-17}
Planck length	10^{-35}

Orders of Magnitude - Mass

	Mass/kg
The universe	10^{53}
The Milky Way galaxy	10^{41}
The sun	10^{30}
The earth	10^{24}
Boeing 747 (empty)	10^{5}
An apple	0.25
A raindrop	10^{-6}
A bacterium	10^{-15}
Smallest virus	10^{-21}
A hydrogen atom	10^{-27}
An electron	10^{-30}

Orders of Magnitude - Time

	Time/s
Age of the universe	10^{17}
Age of the earth	10^{17}
Time of travel by light to nearby star	10^{8}
One year	10^{7}
One day	10^{5}
Period of a heartbeat	1
Period of red light	10^{-15}
Time of passage of light across a nucleus	10^{-24}
Planck time	10^{-43}

Scientific Notation Review

Scientific Notation Review

$$\left(1.75x10^{17}\right)\left(2.82x10^{-5}\right) = \left(1.75 \times 2.82\right)x10^{17+(-5)} = 4.94x10^{12}$$

$$\frac{\left(1.75x10^{17}\right)}{\left(2.82x10^{-5}\right)} = \left(1.75 \div 2.82\right)x10^{17-(-5)} = 0.62x10^{22} = 6.20x10^{21}$$

$$\left(2.82x10^{-5}\right)^{3} = \left(2.82\right)^{3}x10^{(-5)(3)} = 22.4x10^{-15} = 2.24x10^{-14}$$

SI Units - Systeme Internationale

- **Units and Standards**
  - Unit – name for a measurement commonly used
  - Standard – the device that defines the unit

SI Units - Systeme Internationale

- <u>Meter</u> (m) -- unit of length. The standard for a meter has, at various times, been:
  - Distance from the tip of your nose to the tip of your longest finger when arm is extended horizontally. Problem?
  - One ten-millionth of the distance from the earth's equator to either pole. Problem?
  - Distance between two finely engraved marks on a particular bar of a platinum-iridium alloy. Problem?

SI Units - Systeme Internationale

- Meter (m) -- unit of length. The standard for a meter has, at various times, been:
  - For greater precision and reproducibility, changed in 1960 to 1,650,763.73 wavelengths of an orange light emitted by krypton 86 gas. Problem?
  - Current: length of path traveled by light in 1/299,792,458th's of a second. Problem?

SI Units - Systeme Internationale

- Kilogram (kg) – unit of mass. Equal to the mass of a platinum-iridium alloy bar kept at the Bureau International des Poids et Mesures in France

SI Units - Systeme Internationale

- Second (s) – unit of time. Duration of 9,192,631,770 full oscillations of the electromagnetic radiation emitted in a transition between two hyperfine energy levels in the ground state of a cesium-133 atom

SI Units - Systeme Internationale

- **Ampere (A) – unit of electric current. The amount of current which, when flowing in two parallel conductors 1m apart, produces a force of 2×10^{-7} N on a length of 1m of the conductors.**

SI Units - Systeme Internationale

- **<u>Kelvin (K) </u>– unit of temperature. It is 1/273.16th of the thermodynamic temperature of the triple point of water.**

SI Units - Systeme Internationale

- <u>Mole (mol)</u> – One mole of a substance contains as many molecules as there are atoms in 12g of carbon-12. This special number of molecules is called Avagadro's number and is approximately $6.02x10^{23}$.

SI Units - Systeme Internationale

- Candela (cd) – unit of luminous intensity. It is the intensity of a source of frequency 5.40×10^{14} Hz emitting W per steradian. (Not used in our book).

SI Units - Systeme Internationale

- SI Prefixes – Page 5 of Data Guide

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

*Rarely used.

Working With Units

Using Numbers and Units

Working With Units

- Derived units
  - d = m
  - v = m/s
  - a = m/s^2
  - F = ma = N = $kg \cdot m/s^2$
  - W = Fd = J = $kg \cdot m^2/s^2$

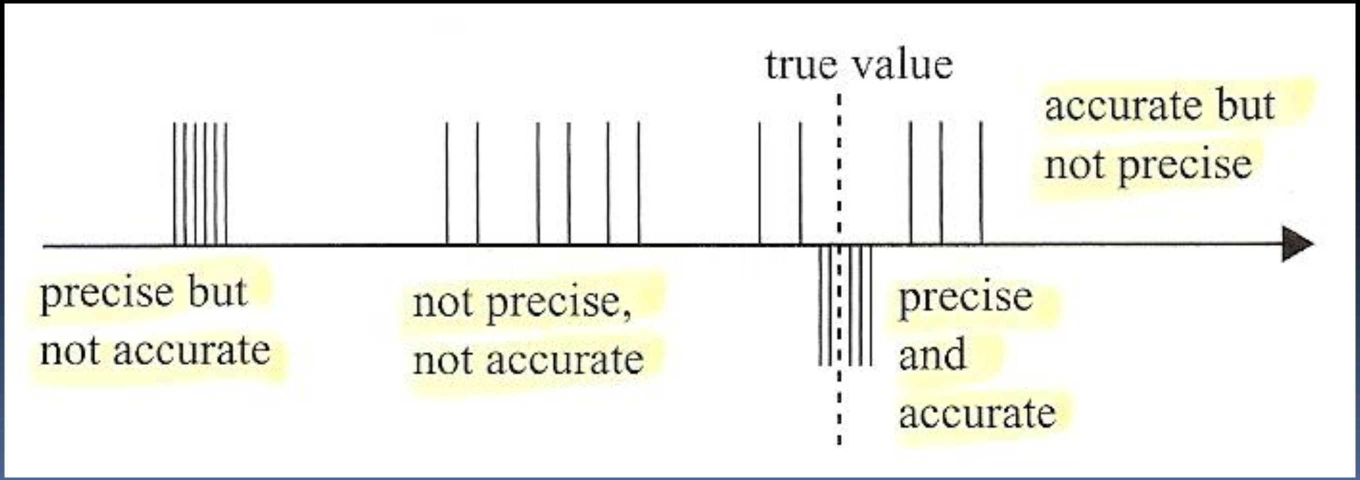
Working With Units

- Ensure the units in an equation are balanced
- Working with constants
  - Convert ‘givens’ to same units as constant

Accuracy and Precision Video

Accuracy and Precision

- Measurements are accurate if the systematic error is small
  - Individual deviations may be high, but mean is close to actual value
- Measurements are precise if random error is small
  - Individual deviations are low, but mean is not significantly different from actual value



Significant Digits – Da Rules

- The leftmost non-zero digit is significant and is in fact the most significant digit in the number.
- If the number has no decimal point, the rightmost non-zero digit is significant and is in fact the least significant.
- If the number does have a decimal point, the least significant digit is the rightmost digit (which may be zero).
- The number of significant digits of a number is the number of digits from the most to the least significant.

Significant Digits – How Many?

63

0.63

0.06301

0.00630

630

630.0

Significant Digits – How Many?

63	2
0.63	
0.06301	
0.00630	
630	
630.0	

Significant Digits – How Many?

63	2
0.63	2
0.06301	
0.00630	
630	
630.0	

Significant Digits – How Many?

63	2
0.63	2
0.06301	4
0.00630	
630	
630.0	

Significant Digits – How Many?

63	2
0.63	2
0.06301	4
0.00630	3
630	
630.0	

Significant Digits – How Many?

63	2
0.63	2
0.06301	4
0.00630	3
630	2
630.0	

Significant Digits – How Many?

63	2
0.63	2
0.06301	4
0.00630	3
630	2
630.0	4

Significant Digits – Scientific Notation

63

0.63

0.06301

0.00630

630

630.0

Significant Digits – Scientific Notation

63 6.3×10^{1}

0.63

0.06301

0.00630

630

630.0

Significant Digits – Scientific Notation

63 | 6.3×10^{1}
0.63 | 6.3×10^{-1}
0.06301
0.00630
630
630.0

Significant Digits – Scientific Notation

63	6.3×10^{1}
0.63	6.3×10^{-1}
0.06301	6.301×10^{-2}
0.00630	
630	
630.0	

Significant Digits – Scientific Notation

63	6.3×10^{1}
0.63	6.3×10^{-1}
0.06301	6.301×10^{-2}
0.00630	6.30×10^{-3}
630	
630.0	

Significant Digits – Scientific Notation

63	6.3×10^{1}
0.63	6.3×10^{-1}
0.06301	6.301×10^{-2}
0.00630	6.30×10^{-3}
630	6.3×10^{2}
630.0	

Significant Digits – Scientific Notation

63	6.3×10^{1}
0.63	6.3×10^{-1}
0.06301	6.301×10^{-2}
0.00630	6.30×10^{-3}
630	6.3×10^{2}
630.0	6.300×10^{2}

Significant Digits

- *In multiplication, division, powers and roots, the result must only have as many significant digits as those of the number with the least number of significant digits entering the operations.*

$$136 \div 0.0072 = 18888.88889 = 1.9x10^4$$

- *In addition and subtraction, the answer must have the same number of digits after the decimal point as the number in the problem with the least number of digits after the decimal.*

$$1.36 + 0.0072 = 1.3672 = 1.37$$

Significant Digits

- Always use the numbers that you have been given, perform the math operations, and ***THEN*** round ***THE ANSWER*** to correct number of significant digits
- Carry all digits in your calculator, write the answer in significant digits
- Defined conversions don't count (1cm = 10mm)
- Constants or derived conversions do (s = 3.00×10^8 m/s) (1 AU = 1.5×10^6 km)

Essential Idea

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QUESTIONS?

Homework

#1-22