General Comments

• Always write out your work so that a reader can follow what you are doing!
• Always write out your unit conversions!
• Most common errors in student’s problem sets are where students do the conversions in their head in <1 second without checking or writing anything down. Results are often hilariously (sadly) very inaccurate.
• Write legibly! If I can’t read your handwriting, then I can’t figure out what you are doing.
• Remember the carpenter’s rule: “measure twice, cut once”
• No one should hire you if you can’t produce quality results! Get in the practice of turning in quality work.
Significant Figures ("sig figs")

- No measurement is known perfectly. All measurements have some “uncertainty” or “error” (or “error bar” when plotted).
- Measuring quantities to higher precision means we can quote more digits. If uncertainty is not explicitly given (e.g. 3.5±0.3), then we assume uncertainty is in last digit, i.e. 3.5 has assumed error ±0.1.
- 3 has 1 sig fig. 3.1 has 2 sig figs. 3.15 has 3 sig figs. etc.
- Leading zeroes are never significant.
- Zeroes within a number are always sig (e.g. 3.05 has 3 sig figs).
- Trailing zeros can be significant, but not zeroes that just hold decimal place (e.g. 400 has 1 sig figs, but “400.” has 3 sig figs, and 400.0 has 4 sig figs). If uncertain whether trailing zero is sig fig, then assume not.
- Rounding: Depends whether last digit is > or < than 5.
e.g. 1.606 becomes 1.61; 1.604 becomes 1.60.

Significant Figures ("sig figs")

- When values are added or subtracted, or multiplied or divided, the final answer should contain no more decimal places than the least accurate value.
- Most physical/chemical/astronomical constants are known to greater precision than your measurements (with Newtonian G being a typical exception), so make sure you are using constants to sufficient precision. e.g. an “AU” is now defined as exactly 149,597,870.700 meters. One can’t justify using “150 million km” in your calculations unless your other values have <=2 sig figs.
- Don’t round too early – If you need to write out intermediate steps (calculate intermediate values), make sure you’ve retained your sig figs (or keep at least 1-2 extra) so that you are not losing precision in the calculation. But make sure you get the number of sig figs correct in your final answer.
**Accuracy vs. Precision**

- **Accurate** (but not precise)
  - Note: repeated "accurate" measurements will eventually get a "more accurate" answer!

- **Precise** (but not accurate)
  - Note: repeated measurements that are "precise" but not "accurate" will lead to "systematic errors" and get you into trouble!

- **Accurate & Precise**
  - Bullseye

**Astronomically Big Numbers**

- Get to know the scale of things. Students often calculate ridiculously inaccurate values off by orders of magnitude (factors of 10) and don’t seem to recognize their errors.
- **Masses**: Sun (2e30 kg), Jupiter (2e27 kg), Earth (6e24 kg), Moon (7e22 kg).
- **Radii**: Sun (696,000 km), Jupiter (71,492 km), Earth (6378 km), Moon (1738 km)
- **Astronomical Unit**: 149,597,870.700 km
- **Orbital radii**: Earth (1AU), Mars (1.5 AU), Jupiter (5.2 AU), Neptune (30 AU), etc. Parsec = 206265 AU
- **Power**: Sun (3.83e26 Watts)
- **Ages**: universe (13.7 Gyr), solar system (4.6 Gyr).
Common Metric prefixes

You should be able to recall them instantly.

The most common are: giga, mega, kilo, centi, milli, micro, and nano.

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Angles and Angular Sizes

- **Degrees to radians**: Remember 206265 arcseconds per radian (180/pi ~ 57.3 deg).
- **For small angles**:
  
  \[ \text{size} = (\text{angle in radians}) \times (\text{distance}) \]
  
  e.g. size of Moon (1/2 degree wide)
  
  \[ (0.50 \text{ deg})/(57.3 \text{ deg/rad}) \times 384400 \text{ km} = 3400 \text{ km} \]