Physics 210 **NAME:**

Homework 1: Measurements One or two full answer questions will be marked. There will also be a mark for completeness. They are due usually the day after the chapter they are for is finished. Solutions will be posted soon thereafter. The solutions are intended to be (but not necessarily are) super-perfect and often go beyond a fully correct answer.

Answer Table

Name:

	a	b	c	d	e
1.	O	O	O	O	O
2.	O	O	O	O	O
3.	O	O	O	O	O
4.	O	O	O	O	O
5.	O	O	O	O	O
6.	O	O	O	O	O
7.	O	O	O	O	O
8.	O	O	O	O	O
9.	O	O	O	O	O
10.	O	O	O	O	O
11.	O	O	O	O	O
12.	O	O	O	O	O
13.	O	O	O	O	O
14.	O	O	O	O	O
15.	O	O	O	O	O
16.	O	O	O	O	O
17.	O	O	O	O	O
18.	O	O	O	O	O
19.	O	O	O	O	O
20.	O	O	O	O	O
21.	O	O	O	O	O
22.	O	O	O	O	O
23.	O	O	O	O	O
24.	O	O	O	O	O
25.	O	O	O	O	O
26.	O	O	O	O	O
27.	O	O	O	O	O
28.	O	O	O	O	O
29.	O	O	O	O	O
30.	O	O	O	O	O

	a	b	c	d	e
31.	O	O	O	O	O
32.	O	O	O	O	O
33.	O	O	O	O	O
34.	O	O	O	O	O
35.	O	O	O	O	O
36.	O	O	O	O	O
37.	O	O	O	O	O
38.	O	O	O	O	O
39.	O	O	O	O	O
40.	O	O	O	O	O
41.	O	O	O	O	O
42.	O	O	O	O	O
43.	O	O	O	O	O
44.	O	O	O	O	O
45.	O	O	O	O	O
46.	O	O	O	O	O
47.	O	O	O	O	O
48.	O	O	O	O	O
49.	O	O	O	O	O
50.	O	O	O	O	O
51.	O	O	O	O	O
52.	O	O	O	O	O
53.	O	O	O	O	O
54.	O	O	O	O	O
55.	O	O	O	O	O
56.	O	O	O	O	O
57.	O	O	O	O	O
58.	O	O	O	O	O
59.	O	O	O	O	O
60.	O	O	O	O	O

1. In physics jargon, the word “clearly” means:

   a) clearly. b) unclearly. c) after 4 pages of algebra. d) wrongly. e) all of the above.

2. In physics jargon, the phrase “must be” means:

   a) is. b) just accept it that. c) not necessarily so. d) can’t be. e) all of the above.

3. “Let’s play *Jeopardy*! For $100, the answer is: It is a notation in which one expresses a number by a coefficient decimal number multiplied explicitly by 10 to the appropriate power. If the coefficient is in the range 1 to 10, but not including 10, the notation is called normalized.”

   What is ____________, Alex?

   a) British notation b) scientific notation c) metric notation d) tensy notation
   e) Irish notation

4. Write a hundred million billion miles in scientific notation.

   a) 10^2 mi. b) 10^6 mi. c) 10^9 mi. d) 10^{17} mi. e) 10^{-9} mi.

5. Express 4011 and 0.052 in normalized scientific notation form.

   a) 4.011×10^3 and 5.2×10^{-2}. b) 40.11×10^3 and $52. \times 10^{-2}$.
   c) 40.11×10^2 and $52. \times 10^{-3}$. d) 4.011×10^{-2} and 5.2×10^3. e) 4011 and 0.052.

6. “Let’s play *Jeopardy*! For $100, the answer is: In any measurements of quantities, they are conventionally agreed upon standard things.”

   What are ____________, Alex?

   a) unities b) dualities c) duplicities d) quantons e) units

7. The modern standard set of units for science, most engineering, and much of everyday life (except in the 2nd largest country in North America) is the International System of Units (Système International d’Unités or SI) which is often called the:

   a) British system. b) Mesopotamian system. c) metric system. d) Paraguayan system.
   e) rational system.

8. Why is the US Customary Unit system (loosely called the British Unit System) hard to use in calculations in comparison with the metric system?

   a) The US Customary Unit system has no unit of mass. Consequently, when you need to use mass, you have to mentally work around the lack of a unit.
   b) The US Customary Unit is completely unknown by scientists and engineers, and so, of course, could scarcely be used.
   c) The US Customary Unit has units in a host of irregular sizes: 16 ounces to the pound, 8 pints in a gallon, 12 inches to the foot, and 45 inches to the ell (fact!). This makes calculations and conversions tortuous. In particular, it is awkward that cubic units of length (e.g., cubic inches, feet, etc.) are not simply related to standard volume units (e.g., a U.S. gallon is defined as 231 cubic inches). In everyday life the irregularities of the British system don’t cause much of a problem and maybe even have mnemonic value. But that hardly helps people who want to send probes to Mars.
   d) The complete regularity of the US Customary Unit means that you never know if a number is 10, 100, 1000, etc., except by context.
   e) It’s the revenge for Bunker Hill.

9. Three quantities usually adopted as basic (i.e., not reducible to other kinds of quantities by convention) are:

   a) length, area, volume. b) mass, weight, heft. c) length, mass, time.
   d) time, duration, age. e) length, mass, density.

10. The 7 base units are meter, kilogram (gram would have been more logical), second, ampere,

    a) kelvin, mole, and candela. b) calvin, mold, and candeleria.
    c) kelvin, mouse, and candace. d) melvin, moose, and cantrip.
    e) kludge, moor, and mountain.

11. MKS stands for:

    a) meters, kilometers, centimeters. b) meters, kilometers, seconds.
    c) meters, kilograms, seconds. d) millimeters, kilometers, seconds.
    e) millimeters, kilograms, seconds.

12. If one used **ONLY** MKS units (i.e., units of meters, kilograms, seconds, coulombs, amperes, kelvins, moles, etc., plus MKS units derived from these) in calculations, then one will get answers in:

    a) CGS units only. b) MKS or CGS units. c) MKS units only. d) British units only.
    e) any old units.

13. In scientific calculations, it is probably best to stick to one complete, consistent set of units (MKS or CGS):

    a) always. b) half the time. c) never. d) whenever. e) except when its not convenient. In most specialized studies, there are units convenient for that study either in actual calculations or just in mental conception. Astronomers, for example often use the solar mass (1.9891×10^{30} kg) as a unit for the masses of stars since the Sun is basic standard of reference for stars.

14. In SI, the prefixes kilo and centi indicate, respectively, multiplication by:

    a) 1000 and 0.01. b) 0.01 and 1000. c) 1000 and 100. d) 60 and 0.01. e) π and e.

15. In conversions, one can just treat units as variables whose values are never specified. One can do algebra with them and cancel them. One also knows a set of equalities relating units, and so can write down factors of unity or conversion factors. For example, $1000\,\mathrm{m} = 1\,\mathrm{km}$, and so a factor of unity (or conversion factor) is

    $$1 = \frac{1000\,\mathrm{m}}{1\,\mathrm{km}} .$$

    This factor would be used to convert an amount in kilometers to meters by:

    a) multiplication. b) division. c) addition. d) subtraction. e) squaring.

16. A units conversion factor is sometimes called a factor of:

    a) unity. b) 2. c) a few. d) 10. e) fact.

17. Using compact one-number conversion factors is often trickier than just using explicit factors of unity in doing calculations. But if one has to do repeated conversions, it is convenient to have them. Some are straightforward to find. For example, what is the conversion factor for converting meters **TO** centimeters?

    a) 100 cm/m. b) (1/100) cm/m. c) (1/10) cm/m. d) 10 cm/m. e) 10 m/cm.

18. Using compact one-number conversion factors is often trickier than rather than just using explicit factors of unity in doing calculations. But if one has to do repeated conversions, it is convenient to have them. Some are straightforward to find and others a little less so. For example, what is the conversion factor for converting meters per second **TO** kilometers per hour? **HINT:** Start with the $1\,\mathrm{m/s} = 1\,\mathrm{m/s} \times 1 \times 1$ and replace the 1's by simple factors of unity and find a factor of unity for required conversion and then the compact one-number conversion factor.

    a) 3.6 (km/h)/(m/s). b) 1/3.6 (km/h)/(m/s). c) 1000 (km/h)/(m/s).
    d) 3600 (km/h)/(m/s). e) 1000/3600 (km/h)/(m/s).

19. A kilogram is:

    a) 1000 grams. b) 1×10^{-3} grams. c) 3.1416 grams. d) 2 grams. e) 0 grams.

20. One inch is:

    a) 1 m. b) 1 km. c) 1 cm. d) 2.54 cm. e) 1 ft.

21. 1 mile is nearly exactly:

    a) 1 m. b) 1 km. c) 1.609 km. d) 2.54 cm. e) 1 ft.

22. A human (a very speedy human) can run 10 m/s. What is this speed in miles per hour (mi/h)? **HINT:** You do not need to do any explicit calculation (although that will work too). Just think about everyday reality. Can you outrun a car? Yes/no/maybe?

    a) 100 mi/h. b) 1 mi/h. c) 11.2 km/s. d) 22.37 mi/h. e) 22.37 miles.

23. Exactly how many seconds are there in a day? How many seconds are there in a day to order of magnitude? **HINT:** "To order of magnitude" means that the number is rounded off to the nearest power of 10. There is no universal rule about the dividing line between rounding down and rounding up. However, using $\sqrt{10} \approx 3.162$ is a reasonable choice. Thus, the prefix number in normalized scientific notation is rounded down to 1 if it is less than $\sqrt{10}$, rounded up to 10 if it is larger than $\sqrt{10}$, and rounded to make an even power of 10 if it is exactly $\sqrt{10}$. For example, 2.2 rounds off to $10^0 = 1$, 991 rounds off to 10^3, and $\sqrt{10000} = \sqrt{10} \times 10^2$ rounds off to 10^2.

    a) 86400 s and 10^4 s. b) 1440 s and 10^4 s. c) 1440 s and 10^5 s. d) 86400 s and 10^5 s. e) $\pi \times 10^7$ s.

24. **CONVERT** a hundred million billion miles into kilometers.

    a) 1.6×10^2 km. b) 1.6×10^6 km. c) 1.6×10^9 km. d) 1.6×10^{17} km. e) 1.6×10^{-9} km.

25. Multiply experimental values 3.27 and 9.9, and give the answer to correct significant figures.

    a) 30. b) 34. c) 32. d) 32.3. e) 32.4.

26. Add and multiply 3.01×10^2 and 1.1×10^{-1} rounding off to significant figures.

    a) 3.0111×10^2 and 3.311×10^1. b) 3.01×10^2 and 3.311×10^1. c) 3.0111×10^2 and 3.3×10^1. d) 3.01×10^2 and 3.3×10^1. e) 3.0×10^2 and $3. \times 10^1$.

27. American hydraulic engineers often use acre-feet to measure volume of water. An acre-foot is the amount of water that will cover an acre of flat land to 1 foot.

    a) Say 3.00 in of rain fell on a plain of 30.0 km^2. How many acre-feet of water fell? Note 1 square mile equals 640 acres and 1 mi = 1.609344 km exactly by the mile definition. **HINTS:** First, find the volume in the hybrid units of inch-km^2 and then use a separate factor of unity for each unit conversion: divide and conquer.

    b) Now do a perhaps more useful calculation. Find the conversion factor from acre-feet to cubic meters. Note that 1 in = 2.54 cm exactly by the modern inch definition.

28. Italian-American physicist Enrico Fermi once noted that a standard 50 minute university lecture was nearly a micro-century. **NOTE:** A Julian year, which is exactly 365.25 days, is exactly 3.15576×10^7 seconds. Actually, a convenient mnemonic is that a Julian year is $\pi \times 10^7$ s which is too small by only 0.5 %. It just a coincidence that the Julian year is almost this number of seconds. More exactly a Julian year is $1.0045096\pi \times 10^7$ s.

    a) How long is a micro-century in minutes actually?

    b) What is the percentage difference between a standard lecture period and a micro-century.

29. The mean Sun-Earth distance, 1.496×10^{13} cm, is a convenient natural unit in astronomy. (All astronomy is CGS, not MKS by the by.) This unit is called the astronomical unit. Given the speed of light is approximately 3.00×10^8 m/s, what is the light travel time from the Sun in minutes?

30. Pulsar PSR 1937+21 has rotation period 1.55780644887275(3) ms, where the bracketed number is the uncertainty in the last digit. Note "ms" is millisecond, not microsecond which has symbol μs.

    a) How many times does the pulsar rotate in 1.0 days keeping track of significant figures?

    b) How many times does the pulsar rotate in exactly 1 day (i.e., 1.0000 . . . days) keeping track of significant figures insofar as your calculator allows?

31. The mean solar day is known to increase secularly (i.e., in a long-term way) by about 1.70×10^{-3} seconds per century due mainly to the tidal interaction of the Moon and Sun (Wikipedia: Tidal acceleration).

Currently, the mean solar day is about 86400.002 seconds long (Wikipedial: Solar time). **HINT:** Both parts (a) and (b) are questions of how long at a given rate does a given amount take to accumulate.

a) About how often does a leap second need to be introduced in standard time in order to keep standard and solar time synchronized?

b) If the current rate of increase in the day continues, about how long in years will it take before a leap second is needed daily: i.e., how long until the mean solar day is about 86401.0 seconds?

Equation Sheet for Introductory Physics Calculus-Based

This equation sheet is intended for students writing tests or reviewing material. Therefore it is neither intended to be complete nor completely explicit. There are fewer symbols than variables, and so some symbols must be used for different things: context must distinguish.

The equations are mnemonic. Students are expected to understand how to interpret and use them.

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1 Constants

$$c = 2.99792458 \times 10^8\,\mathrm{m/s} \approx 2.998 \times 10^8\,\mathrm{m/s} \approx 3 \times 10^8\,\mathrm{m/s} \approx 1\,\mathrm{lyr/yr} \approx 1\,\mathrm{ft/ns} \qquad \text{exact by definition}$$

$$e = 1.602176487(40) \times 10^{-19}\,\mathrm{C}$$

$$G = 6.67428(67) \times 10^{-11}\,\mathrm{N\,m^2/kg^2} \qquad (2006, \text{CODATA})$$

$$g = 9.8\,\mathrm{m/s^2} \qquad \text{fiducial value}$$

$$k = \frac{1}{4\pi\varepsilon_0} = 8.987551787\ldots \times 10^9 \approx 8.99 \times 10^9 \approx 10^{10}\,\mathrm{N\,m^2/C^2}\text{exact by definition}$$

$$k_{\mathrm{Boltzmann}} = 1.3806504(24) \times 10^{-23}\,\mathrm{J/K} = 0.8617343(15) \times 10^{-4}\,\mathrm{eV/K} \approx 10^{-4}\,\mathrm{eV/K}$$

$$m_e = 9.10938215(45) \times 10^{-31}\,\mathrm{kg} = 0.510998910(13)\,\mathrm{MeV}$$

$$m_p = 1.672621637(83) \times 10^{-27}\,\mathrm{kg} = 938.272013(23), \mathrm{MeV}$$

$$\varepsilon_0 = \frac{1}{\mu_0 c^2} = 8.8541878176\ldots \times 10^{-12}\,\mathrm{C^2/(N\,m^2)} \approx 10^{-11} \qquad \text{vacuum permittivity (exact by definition)}$$

$$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{N/A^2} \qquad \text{exact by definition}$$

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2 Geometrical Formulae

$$C_{\mathrm{cir}} = 2\pi r \qquad A_{\mathrm{cir}} = \pi r^2 \qquad A_{\mathrm{sph}} = 4\pi r^2 \qquad V_{\mathrm{sph}} = \frac{4}{3}\pi r^3$$

$$\Omega_{\mathrm{sphere}} = 4\pi \qquad d\Omega = \sin\theta\, d\theta\, d\phi$$

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3 Trigonometry Formulae

$$\frac{x}{r} = \cos\theta \qquad \frac{y}{r} = \sin\theta \qquad \frac{y}{x} = \tan\theta = \frac{\sin\theta}{\cos\theta} \qquad \cos^2\theta + \sin^2\theta = 1$$

$$\csc\theta = \frac{1}{\sin\theta} \qquad \sec\theta = \frac{1}{\cos\theta} \qquad \cot\theta = \frac{1}{\tan\theta}$$

$$c^2 = a^2 + b^2 \qquad c = \sqrt{a^2 + b^2 - 2ab\cos\theta_c} \qquad \frac{\sin\theta_a}{a} = \frac{\sin\theta_b}{b} = \frac{\sin\theta_c}{c}$$

$$f(\theta) = f(\theta + 360^\circ)$$

$$\sin(\theta + 180^\circ) = -\sin(\theta) \qquad \cos(\theta + 180^\circ) = -\cos(\theta) \qquad \tan(\theta + 180^\circ) = \tan(\theta)$$

$$\sin(-\theta) = -\sin(\theta) \qquad \cos(-\theta) = \cos(\theta) \qquad \tan(-\theta) = -\tan(\theta)$$

$$\sin(\theta + 90^\circ) = \cos(\theta) \qquad \cos(\theta + 90^\circ) = -\sin(\theta) \qquad \tan(\theta + 90^\circ) = -\tan(\theta)$$

$$\sin(180^\circ - \theta) = \sin(\theta) \qquad \cos(180^\circ - \theta) = -\cos(\theta) \qquad \tan(180^\circ - \theta) = -\tan(\theta)$$

$$\sin(90^\circ - \theta) = \cos(\theta) \qquad \cos(90^\circ - \theta) = \sin(\theta) \qquad \tan(90^\circ - \theta) = \frac{1}{\tan(\theta)} = \cot(\theta)$$

$$\sin(a + b) = \sin(a)\cos(b) + \cos(a)\sin(b) \qquad \cos(a + b) = \cos(a)\cos(b) - \sin(a)\sin(b)$$

$$\sin(2a) = 2\sin(a)\cos(a) \qquad \cos(2a) = \cos^2(a) - \sin^2(a)$$

$$\sin(a)\sin(b) = \frac{1}{2}\left[\cos(a - b) - \cos(a + b)\right] \qquad \cos(a)\cos(b) = \frac{1}{2}\left[\cos(a - b) + \cos(a + b)\right]$$

$$\sin(a)\cos(b) = \frac{1}{2}\left[\sin(a - b) + \sin(a + b)\right]$$

$$\sin^2\theta = \frac{1}{2}[1 - \cos(2\theta)] \qquad \cos^2\theta = \frac{1}{2}[1 + \cos(2\theta)] \qquad \sin(a)\cos(a) = \frac{1}{2}\sin(2a)$$

$$\cos(x) - \cos(y) = -2\sin\left(\frac{x + y}{2}\right)\sin\left(\frac{x - y}{2}\right)$$

$$\cos(x) + \cos(y) = 2\cos\left(\frac{x + y}{2}\right)\cos\left(\frac{x - y}{2}\right)$$

$$\sin(x) + \sin(y) = 2\sin\left(\frac{x + y}{2}\right)\cos\left(\frac{x - y}{2}\right)$$

4 Approximation Formulae

$$\frac{\Delta f}{\Delta x} \approx \frac{df}{dx} \qquad \frac{1}{1 - x} \approx 1 + x \;:\; (x << 1)$$

$$\sin\theta \approx \theta \qquad \tan\theta \approx \theta \qquad \cos\theta \approx 1 - \frac{1}{2}\theta^2 \qquad \text{all for } \theta << 1$$

5 Quadratic Formula

$$\text{If} \qquad 0 = ax^2 + bx + c\,, \qquad \text{then} \qquad x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = -\frac{b}{2a} \pm \sqrt{\left(\frac{b}{2a}\right)^2 - \frac{c}{a}}$$