

Physics 350 Problem Set 1 (Spring Semester 2009)
Due Thu., January 22 at 4:30PM

Our Expectations:

- Full credit on problem sets will only be given to students who clearly show us not only their mathematical approach to the answer, but clearly state their reasoning. We expect a minimum of a few sentences in each problem explaining your thinking in addition to any math. And always cite the sources of any equations you use.
- You may work together in groups on the problem sets. However, the work you present must be your own. You will get little out of the problem sets if you just copy someone else's solutions. To avoid the appearance of plagiarism, I would also strongly suggest you state clearly who, if anyone, you worked with on your homework.

Expected Reading: In preparation for this assignment, we expect you to read Boas, Chapter 1.12 to 1.14 and Chapter 2.1 to 2.5.

1. Find the Taylor series expansion of the function $x^{\frac{1}{3}}$ about $x_0 = 8$. Keep terms up to and including third order.
2. Show that the Taylor series expansion about $x_0 = 0$ for the exponential is given by

$$e^x = 1 + x + \frac{x^2}{2} + \frac{x^3}{3!} + \cdots = \sum_{n=0}^{\infty} \frac{x^n}{n!}. \quad (1)$$

3. The energy of a particle in special relativity is given by

$$E = \frac{m_0 c^2}{\sqrt{1 - (v/c)^2}}. \quad (2)$$

- (a) For small speeds, when $v/c \ll 1$, the energy ought to reduce to the sum of two pieces, the rest energy $m_0 c^2$ and the usual kinetic energy $mv^2/2$. Check that it does by expanding (??) to second order about the point $v_0 = 0$.
- (b) What does this result mean in terms of our understanding of physics.

4. Use Maple to find the value of the indefinite integral

$$\int t \cos(t) e^{-t} dt. \quad (3)$$

5. The average square speed of a molecule in a gas is given by

$$\langle v^2 \rangle = \frac{\int_0^\infty 4\pi N v^4 e^{-mv^2/2kT} dv}{\int_0^\infty 4\pi N v^2 e^{-mv^2/2kT} dv}. \quad (4)$$

Use Maple to find this average square speed in terms of m , k , and T .
Hint: Cancel out whatever factors you can in the ratio *before* entering anything into Maple.

6. For each number below, give the numerical value of its real part x , its imaginary part y , its modulus r , and one value of angle θ . In addition, find the complex conjugate of each number. *Hint:* First, simplify each number to the cartesian form $x + iy$ or to the polar form $re^{i\theta}$.

(a) $4 \left(\cos \frac{2\pi}{3} - i \sin \frac{2\pi}{3} \right)$ *Boas* Problem 2.4.12, p. 51

(b) $\sqrt{2}e^{-i\pi/4}$ *Boas* Problem 2.4.17, p. 51

(c) $(i + \sqrt{3})^2$ *Boas* Problem 2.5.5, p. 52

(d) $\frac{5-2i}{5+2i}$ *Boas* Problem 2.5.15, p. 52