

Phys 375 HW 1

Fall 2009

6 Problems Due 23/24 September, 2009

1. Error analysis.

(a) For the following list of data, calculate the mean, mode, median, standard deviation, and variance. Do this by writing an *explicit* MATLAB/Octave script (i.e. do NOT use built-in functions mean, std, var, etc.).

0.91595 0.35290 0.35692 0.18598 0.67537 0.92017 0.98268 0.44933 0.27089
0.81826

Show how you can use your script to calculate the same parameters for 1000 random numbers between 0 and 1.

(b) Write a script that generates a Gaussian distribution of random numbers with a given mean and standard deviation. Use this script to verify that the standard deviation of the mean is reduced to zero as the number of distribution samples increases.

(c) Calculate the standard deviation of your data from “Experiment 0”. Use this information to determine the divergence angle of the laser beam. Then, determine the distance of the beam waist from the laser aperture, the size of the beam waist, and the Rayleigh length. [Hint: calculation of standard deviation from noisy data is very sensitive to outliers. Only analyze data “near” the expected value of the mean.]

2. Error propagation.

You are trying to determine the acceleration due to gravity g by measuring the period of a

pendulum, T , of length L using the relation $T = 2\pi\sqrt{\frac{L}{g}}$. The summary of measured data is T

$= 3.818 \pm 0.009$ sec, and $L = 361.58 \pm 0.40$ cm. By propagating errors, determine the best value and uncertainty in g . If you could go back and revise the experiment, which quantity would you want to measure more precisely?

3. Pedrotti, 3rd edition, problem 1-3.

4. Pedrotti, 3rd edition, problem 1-15.

5. An electromagnetic wave is specified (in SI units) by the following function:

$$\vec{E} = (-6\hat{i} + 3\sqrt{5}\hat{j})(10^4 \text{ V/m}) \exp\left[i\left\{\frac{1}{3}(\sqrt{5}x + 2y)\pi \times 10^7 - 9.42 \times 10^{15} t\right\}\right]$$

Find

(a) the direction along which the electric field oscillates,

(b) the scalar value of amplitude of electric field,

(c) the direction of propagation of the wave,

(d) the propagation number and wavelength,

(e) the frequency and angular frequency, and

(f) the speed.

6. An underwater swimmer shines a beam of light up toward the surface. It strikes the air-water interface at 35° . At what angle will it emerge into the air?