

# SIMG-303-20033 Homework #1

## Due W, 3/17/2004

0. Do the following, though there is nothing to hand in.
  - (a) Read Hecht Chapters 1 and 2
  - (b) Go to Wallace Library and find the shelf location where books on Optics are kept (QC and TA). Pull out a few of the books that appear to be relevant to imaging and look them over.

Solve the following problems. You may “plot” any results requested by computer, BUT include the graphs with the problem, NOT as a cluster of printouts at the beginning or end of the assignment.

1. A source of harmonic motion of the form  $y(t) = 6 \cdot \cos(\omega_0 t)$  located at the origin of the spatial coordinate system emits a wave that travels through a uniform (i.e., homogeneous) medium at a rate of 60 mm per second.
  - (a) Find the formula for the displacement due to this wave at a distance of 800 mm from the origin.
  - (b) Find the displacement at that distance for  $t = 60$  s.  
(HINT: It is ALWAYS useful to draw a diagram of the problem before trying to solve it!)
2. Find expressions for the sums of the following pairs of waves AND sketch the sum (you may “plot” the result by computer if you wish), i.e., for  $f_1[x]$  and  $f_2[x]$  in each case, find  $g[x] = f_1[x] + f_2[x]$ 
  - (a)  $f_1[x] = 2 \cdot \cos[2\pi\xi_0 x]$ ,  $f_2[x] = 2 \cdot \cos[2\pi\xi_0 x]$
  - (b)  $f_1[x] = 2 \cdot \cos[2\pi\xi_0 x]$ ,  $f_2[x] = \cos[2\pi\xi_0 x]$
  - (c)  $f_1[x] = 2 \cdot \cos[2\pi\xi_0 x]$ ,  $f_2[x] = \cos[2\pi\xi_0 x + \frac{\pi}{2}]$
  - (d)  $f_1[x] = \cos[2\pi\xi_0 x]$ ,  $f_2[x] = \cos[2\pi\xi_0 x - \frac{\pi}{4}]$
3. Use the Euler relation:  $\exp[i\theta] = \cos[\theta] + i \sin[\theta]$  to derive expressions for the following in terms of  $\cos[\theta_1]$ ,  $\sin[\theta_1]$ ,  $\cos[\theta_2]$ , and  $\sin[\theta_2]$ :
  - (a)  $\cos[2\theta_1]$
  - (b)  $\cos[\theta_1] \cdot \cos[\theta_2]$
  - (c)  $\sin[\theta_1 - \theta_2]$

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4. For each of the following complex numbers  $z$ , plot the location of  $z$  on the complex plane (i.e., plot the Argand diagram), plot the complex conjugate  $z^*$ ,  $z^{-1}$ ,  $z + z^*$  and  $z - z^*$

(a)  $z = 1 + 2i$

(b)  $z = \frac{1-4i}{2i}$

(c)  $z = 2 \cdot \exp \left[ i \cdot \frac{3\pi}{4} \right]$

5. Consider two oscillations at different frequencies:

$$f_1 [x] = \cos \left[ 2\pi \frac{x}{2} - \frac{\pi}{2} \right]$$

$$f_2 [x] = \cos \left[ 2\pi \frac{x}{1.8} \right]$$

- (a) Sketch (or plot) the two oscillations separately (preferably on the same graph)
- (b) Sketch (or plot) the sum of the two oscillations over a sufficiently large region of the real axis to get a good idea of the behavior
- (c) Find an expression for this sum as the product of two different sinusoidal oscillations.