Phys106, II-Semester 2019/20 Assignment 5

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Hint: For all these questions (and later ones) you may use the math software `mathematica`*, available from CC. The little overhead in familiarising yourself with it now, will pay off manyfold later, regardless of your major.*

1. (i) Add the two waves $y_1(x,t) = \sin(k_1 x - \omega_1 t + \varphi_1)$ and $y_2(x,t) = \sin(k_2 x - \omega_2 t + \varphi_2)$ to form $y_{tot}(x,t) = y_1(x,t) + y_2(x,t)$ as a product of sine and cosine, similarly to what was done in the lecture (*you may want to look at:* *this collection* .

   (ii) Make a computer script that can plot $y_1(x,t)$, $y_2(x,t)$ and $y_{tot}(x,t)$ and test your calculation is right. For this, use parameters e.g. $k_1 = 1$, $k_2 = 0.9$, $\omega_1 = 1.0$, $\omega_2 = 0.8$, $\varphi_1 = 0$, $\varphi_2 = \pi/2$. Plot $y_{tot}(x,t)$ for couple of values of t.

   (iii) Now fix t and plot for some different values of $\varphi_1 = 0$, $\varphi_2 = 0.1, 0.2, 0.3, \ldots$. What do you see?

2. Download the script fourier_decomposition_gaussian_v1.m (Fourier Demo gaussian) from the webpage. Install matlab from CC at https://www.iiserb.ac.in/cc/download on your computer, or use the computers in CC Lab 1 or 2. Run the script by typing its name (without .m). The bottom shows you a Gaussian wavepacket in black. We now sequentially express this using cosines as in Eq. (42) of the lecture, by pressing ENTER. The violet line shows you the latest added cosine and the red-dashed line the sum of all cosines added so far. The violet dots at the top show you "how much" of a given cosine is added. Once a certain cosine no longer significantly contributes, violet color changes to blue.
   Now you can change the width of the Gaussian wavepacket by changing the parameter d in line 18 slightly up and down. What changes? Discuss.

3. *Await week 6 for this, if we haven't covered it yet:* Find the de-Broglie wave-length of the objects below (treat the all non-relativistically). Discuss your results and expectations. Compare with the sizes of the objects.

   - An electron with velocity 3m/s.
   - An electron with velocity 2000m/s.
   - A proton with velocity $0.04c$.
   - A plane with mass $m = 200$ t and velocity 800km/h.
   - A bacterium with mass $m = 4 \times 10^{-12}$ g and velocity 30μm/s.