ECE 5/6358 HW 1 (150 pts)
First name, Last name

Student ID:

Han Q Le(c)

1.(50 pts) Interest in optics or optoelectronics

Write ~ 0.5-1 page (figures & references included) on a topic in contemporary optics/photonics science and technology that interests you, or you are curious about (*a reason you take this course*).

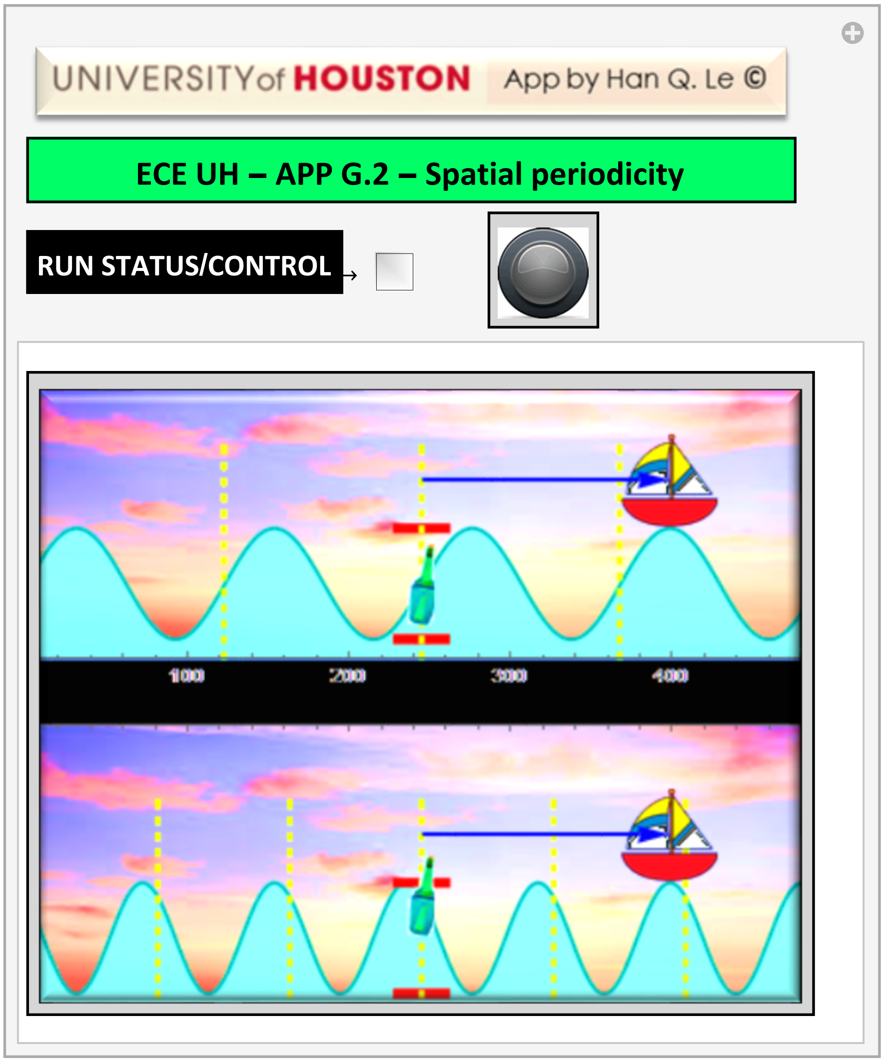
2.(50 pts) Periodic phenomena

Consider three physical phenomena:
- phenomenon ***a***: periodic in time: $u = \text{Cos}[2\,\pi\,f\,t]$ (u is just a variable representing amplitude)
- phenomenon ***b***: periodic in space: $v = \text{Cos}[k\,x]$
- phenomenon ***c***: periodic in both space and time: $q = \text{Cos}[k\,x - 2\,\pi\,f\,t]$

Below is the code that calculates and plots the three phenomena. You don't have to do anything but executing the code, vary various parameters, and observe. Write all you think you learn about the phenomena, especially "***c***". Remember: to see a time phenomenon, run variable time; to see a space-periodic phenomenon, sample (measure) over a range of space; and do both time and space for "***c***"

- *Code for calculation (no need to see, just Shift+ENTER to execute - delete the output - NOT THE CODE - after done)*

App that maybe helpful to HW - use to gain concepts and understanding to do Problem 3 (*this is NOT a problem of the HW*)



3.(50 pts+10 pts bonus) Frequency and wavelength

- We have a group of students who pick 3 wavelengths: 0.65 μm (red DVD laser), 0.532 μm (green laser pointer), 0.405 μm (BluRay laser) (a wavelength, if not specified, is always meant to be in vacuum).
- We have another group of students who pick 2 frequencies: 527 THz and 384 THz. (1 THz = 10^{12} Hz),

Each question below is worth 10 pts - **Answer thoroughly and thoughtfully**.

3.1 Hypothetical waves

If we could (**hypothetically**) make waves that could be from all arbitrary combinations of wavelengths and frequencies, how many waves can we make and what do they look like when traveling. Just run the code and discuss **the single most significant observation**. (if someone tells you that you can say ONLY ONE thing that you notice about the waves below, if it is correct, you will get $1M, and incorrect, $0. Only one. If you make more than one point, you will get zero. What would you say?).

- *Code (no need to see, just Shift+ENTER to execute - delete the output - NOT THE CODE - after done)*

3.2 Identify the waves

All the 6 waves you see above have the form: Cos[$k x - \omega t$] where k is $\frac{2\pi}{\lambda}$ and ω is 2π f. Denote them from 1 (top) to 6 (bottom), Can you match each wave with its λ and f? For example:

wave 1 corresponds to {0.532 μm, 384 THz} (incorrect, but just an example)

3.3 Speed

We learn that the wavespeed is $\frac{\lambda}{T} = \lambda f$ (See the app above again about the wave speed not sure).

Below is the calculation of the 6 wave speeds. The unit is μm/ps.

In[∘]:=
```
Grid[Join[{{"λ", "f", "speed"}},
   ReverseSortBy[Flatten[Table[{v, u, u * v}, {u, f}, {v, λ}], 1], Last]] ,
  BaseStyle → {24, FontFamily → "Calibri"}, Frame → All,
  Background → {{, ,}, {Hue[0.3, 0.4, 1], , , , , ,}}]
```

Out[∘]=

λ	f	speed
0.65	527.	342.55
0.532	527.	280.36
0.65	384.	249.6
0.405	527.	213.44
0.532	384.	204.29
0.405	384.	155.52

Watch the waves in 3.1 again, Can you tell which wave with what wavelength and frequency just by watching? What is the principle behind the approach that you use to identify each wave?

3.4 Given that propagation is such a fundamental property, the speed must be a constant of nature (other wise nature would be a mess)

The speed of light is 299.792458 μm/ps in vacuum, independent of frequency (in 1 ps, light travels about 1/3 of a millimeter, or ~ 6-10 times the width of our hair). Can you calculate the correct frequencies for the 3 wavelengths above and watch how each wave propagates? You only have to calculate f, The code for the wave propagation is given, what is the single most significant feature in the way the waves propagate?

- *Code (no need to see, just Shift+ENTER to execute - delete the output - NOT THE CODE - after done)*

3.5 Speed of light measurement

If you look up any physical quantity, such as those listed on this NIST website:
https://physics.nist.gov/cgi-bin/cuu/Category?view=html&Frequently+used+constants.x=69&Frequently+used+-constants.y=29

almost every quantity has some experimental uncertainty. For the speed of light however, it is exactly 299.792458 μm/ps. No error. Why is that?

3.6 (bonus) Gravitational wave vs light wave speed

On Sept 14, 2015 at ~9:51 UTC, people detected a gravitational wave for the first time. It was a result of two black holes merging. Do an Internet search when that two black holes merged.

it happened a long long time ago in a galaxy far far away.

(1.3 billion light–years)

In the original paper (and on LIGO website), people actually published the experimental uncertainty about the difference between c_L, the speed of light, and c_G, the speed of gravitational wave. Theoretically, they have to be equal for General Relativity to make sense. What is the experimental relative uncertainty of their difference and how was it determined? (read the materials and report).

A good news is that you did look thinner for a moment when the space-compress part of the gravitational wave passed through you (but it stretched you out also for its space-dilation part).