Assignment #9: Computational Graphics in Mathematica

Due on April 28, 2023.

1. Using "Manipulate" to simulate a lab from "Optics Lab":

a. Let's make an ultrasonic interference modeler. First, define some constants using a "regular" equals sign:

$L = 1.2;$	this is the distance between the transmitters and the receiving plane.
$a = 0.14;$	this is the diameter of transmitters.
$d = 0.09;$	this is the spacing between the transmitters.
$\lambda = 0.012.$	this is the wavelength of the sound being emitted.

However, in the long term, I'll really want $0.001 \le a \le 0.1$, $0.05 \le d \le 0.2$, and $0.005 \le \lambda \le 0.05$.

b. Define $\sin 1(\mathrm{x}) = \dfrac{x}{\sqrt{L^2 + x^2}}$, but use a ":=" this time.

c. Next, using a ":=" again, define intensity as a function of x, a, d, and λ. The function is:

$$I(x,a,d,\lambda) = \cos\left(\frac{\pi d}{\lambda}\sin 1(x)\right)^2 \left(\frac{\sin\left(\frac{\pi a}{\lambda}\sin 1(x)\right)}{\frac{\pi a}{\lambda}\sin 1(x)}\right)^2 .$$

Note that the above is NOT Mathematica syntax, it is real syntax. In Mathematica, you'll need to use square brackets for functions, capital letters for function names, underscores after the names of each independent variable when they're on the left hand side of the equals sign, and the ":=" instead of just "=".

d. Create a *variable* representing a plot:

myplot[x_, a_, d_, λ_] := Plot[intensity[x, a, d, λ], {x, -1, 1}, PlotRange -> {0, 1.2}]

e. Show the plot to yourself. This is done by simply typing the plot's name: myplot[x, a, d, λ].

f. Create a "manipulation" of this plot. This is done with a single line:

Manipulate[plotname, slider 1 info, slider 2 info, slider 3 info, slider 4 info, etc.]

For us, the plotname is just myplot[x, a, d, λ].
We want 3 sliders. Each slider info is in the form: {parameter name, param. min, param. max}
The necessary values for the parameters were given to you in part a, above.
Note: if you wanted to add even more sliders, then you have to include those new parameters (with underscores) when you define the intensity and the plot.

g. Submit this Mathematica Notebook to my inbox, with your name in the title.

2. Using Graphics Primitives to draw a FreeFall problem with some added rotations:

a. Open the File "RocketTemplate.nb" from the course homepage.
b. Change the name of the document to include your own name.
c. Look for 7 occurrences of "XXXXXXXXXX". For 4 of them, replace it with the appropriate free-fall formula from Analyt I. For the other 3, provide the appropriate Mathematica definition.
d. Change the value for the variable "path" to something appropriate for *your* computer.
e. Run the simulation. *Look* at the shape of the rocket in the ListPlot before proceeding.
f. Add an exhaust flame to the rocket, in the shape of a diamond (not a square) starting at the back end of the rocket:
   i. Add 4 points to the end of the "xpoints" list. The first new x coordinate will be -0.5.
   ii. Add 4 points to the end of the "ypoints" list. The first new y coordinate will be 0.0.
   iii. Create 4 new line definitions for the diamond's edges. Make them Red or Orange.
   iv. Add these 4 new lines to the final **lines[t_]** list.
g. Experiment: Change $v0$, $\theta 0$, and *len* to see how relative differences change the animation.
h. Open a new PowerPoint document, and insert the animated gif for one set of values.
i. Submit the Mathematica notebook and the PowerPoint.

3. Use "Graphics" to draw a planet orbiting a star:

Remember the PowerPoint assignment from a few weeks ago? Let's make a *simplified* version of one of them now using Mathematica "Graphics": draw a top-view map of a planet orbiting its sun. You will use "Animate" instead of "Manipulate".

a. The background is black.
b. There is a magenta circle showing the path of the orbit.
c. The planet orbits the sun in a counter-clockwise circle with a period of 10 seconds.
d. There is a red "gravity" arrow that moves with the planet but is aimed at the sun.
e. The sun is a white ball with a yellow circular corona. The corona pulses a little in size 4 times per year.

Pay attention to layering! The red arrow is UNDER the blue disc. The magenta line is also under the blue disc. The yellow disc is UNDER the white disc.
You do not need to shade the planet, or make the planet rotate while it orbits.
Consider using the "arrow" graphics tool.
Also, if you're feeling fancy, add in some continents and let them rotate at the rate of 8 "days" per "year".
Submit this as a third mathematica notebook.