Phys106, II-Semester 2019/20, Tutorial 1 solution

Stage 1

(i) Draw the functions $f(x) = \sqrt{x}$, $f(x) = x$, $f(x) = x^2$, $f(x) = x^3$, $f(x) = x^4$ into the same coordinate system.

(ii) Draw the functions $f(x) = \sin(x)$, $f(x) = \cos(x)$ into the same coordinate system.

(iii) Draw the functions $f(x) = \sin(x)$, $f(x) = \sin(x - \pi/4)$, $f(x) = \sin(x - \pi/2)$, into the same coordinate system, discuss what happens to the sine curve.

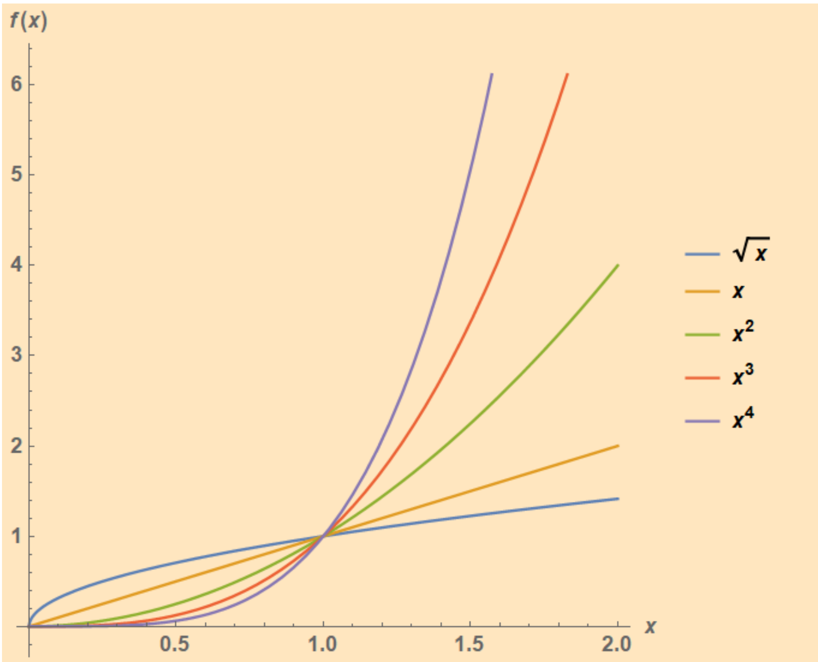
(iv) Draw the function $f(x) = e^x$.

(v) Draw the function $f(x) = e^{-x^2}$.

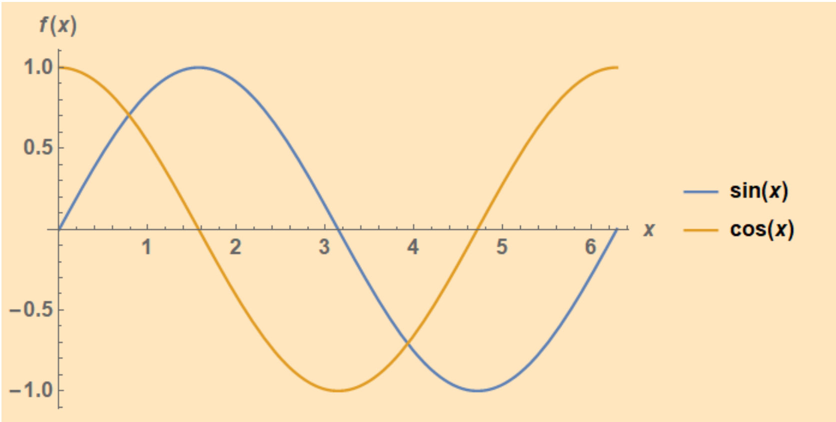
(vi) Draw an arbitrary function $f(x)$ of your choice. *(like the black line in Fig. 1, section 1.2. of the lecture notes, but pick a different function).* Then draw *qualitatively* the derivative $\frac{df(x)}{dx}$ and the second derivative $\frac{d^2f(x)}{dx^2}$.

<u>Solution</u>:

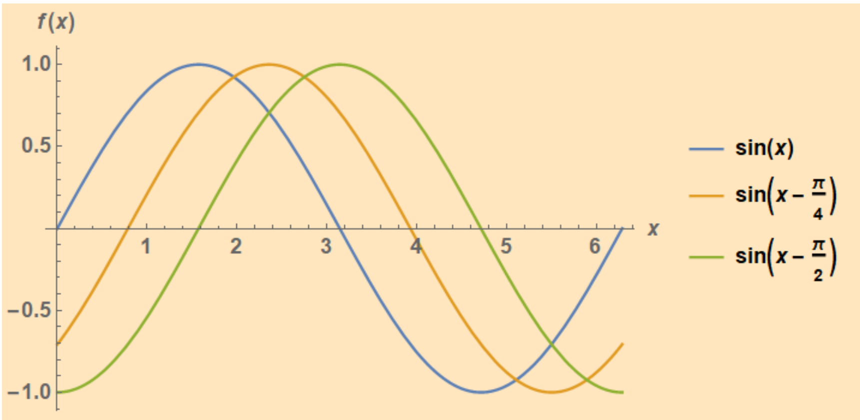
(i)



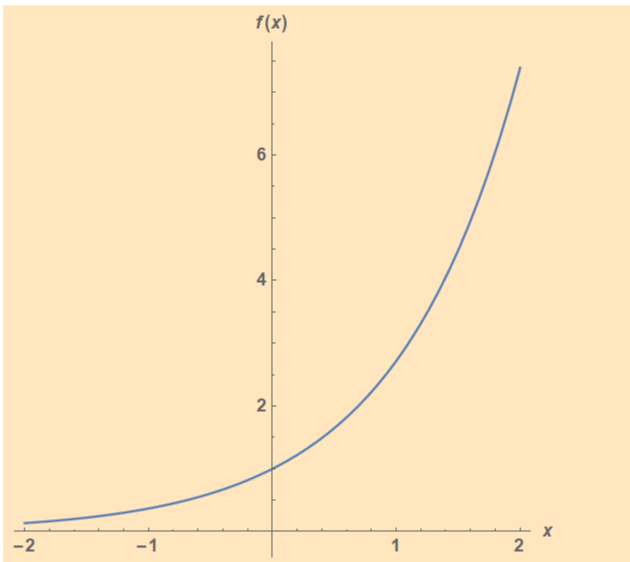
(ii)


f(x)
1.0
0.5
−0.5
−1.0
1
2
3
4
5
6
x
sin(x)
cos(x)

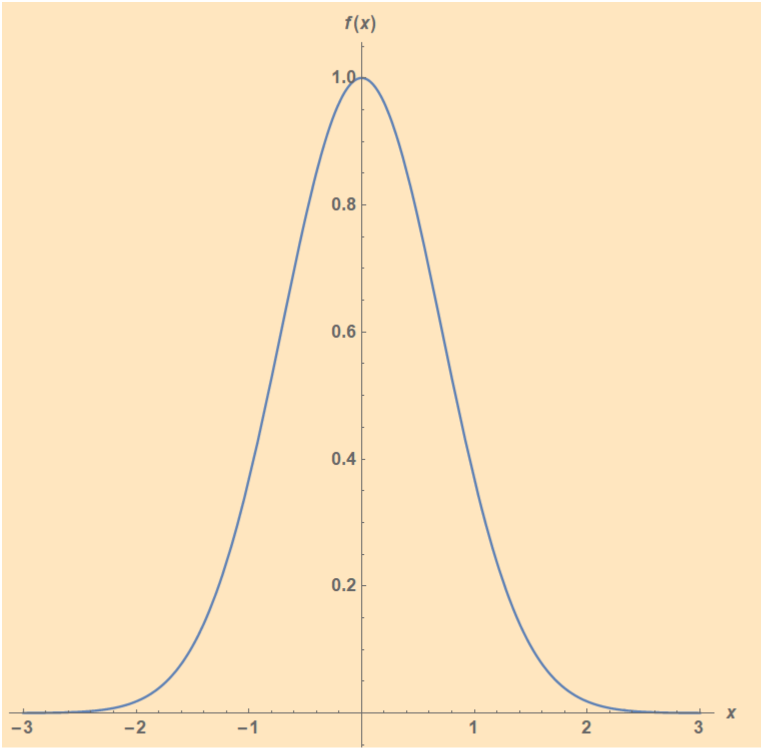
(iii)


f(x)
1.0
0.5
−0.5
−1.0
1
2
3
4
5
6
x
sin(x)
sin(x − π/4)
sin(x − π/2)

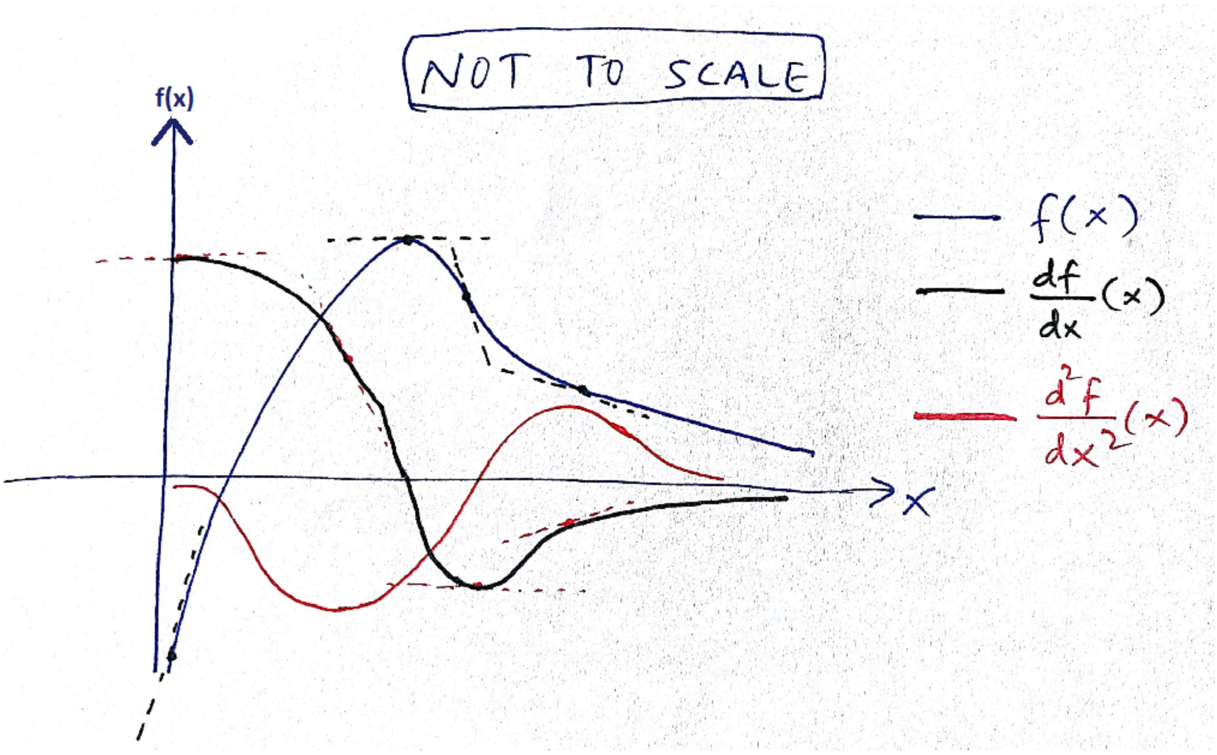
(iv)


f(x)
6
4
2
−2
−1
1
2
x

(v)



(vi)



Stage 2 (i) Draw the following wave forms accurately into the same co-ordinate system: $y(x) = A\sin\left(\frac{2\pi}{\lambda}x + \varphi\right) + B$.

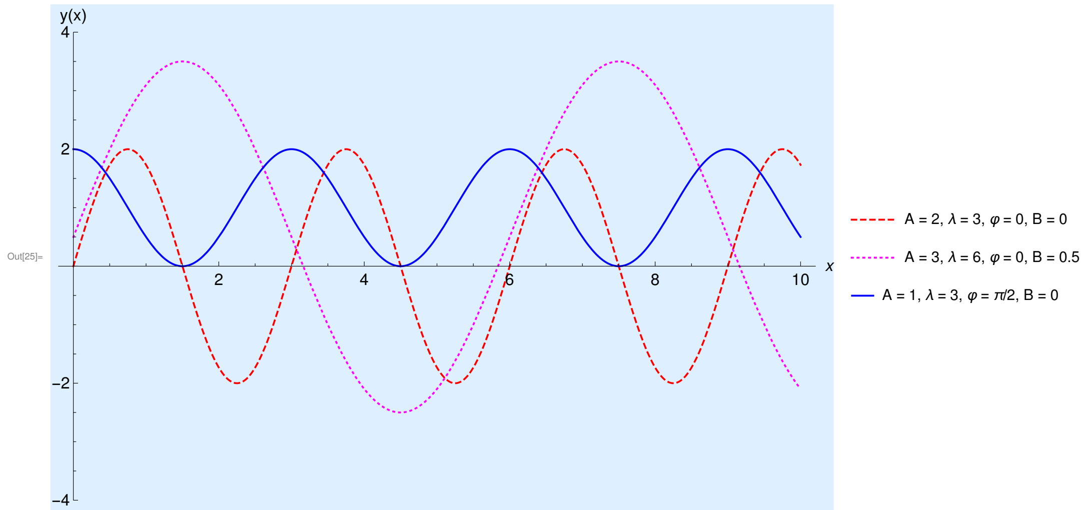
- $A = 2,\ \lambda = 3,\ \varphi = 0,\ B = 0$
- $A = 3,\ \lambda = 6,\ \varphi = 0,\ B = 0.5$
- $A = 1,\ \lambda = 3,\ \varphi = \pi/2,\ B = 1$

(ii) For the following waves, determine amplitude, frequency and phase velocity. What can you say about the units of these? (space is in meters (m) and time in seconds (s)).

- $y(x,t) = A\cos\left(\frac{\pi}{\lambda}x - 2rt + \pi/2\right) - B$
- $y(x,t) = \left[\frac{B}{2}\cos\left(\frac{2\pi}{\lambda}x - 2\pi ft + \varphi\right) + A\right]C$
- $y(x,t) = D\cos\left[\frac{2\pi}{\lambda}(x - \lambda mt) + pt + 42\right] - 2A$

<u>*Solution*</u>*:*

(i)



(ii):

- *Amplitude:* A*, angular frequency:* $2r$*, phase velocity:* $(2\lambda r/\pi)$

- *Amplitude:* $BC/2$*, frequency:* f*, phase velocity:* $f\lambda$

- *Amplitude:* D*, angular frequency:* $p - 2\pi m$*, phase velocity:* $(p - 2\pi m)\lambda/2\pi$.

You don't know the units of A, since we do not tell you what type of wave it is. Unit of frequency is s^{-1}*, for phase velocity* m/s*.*

Stage 3 *(i) Do experiments with a driven Harmonic oscillator. Use the pendulum you brought or the online app at: https://www.walterfendt.de/html5/phen/resonance_en.htm or even better both. In the online app, use all the setting. Note: you have to stop animation with "reset" to change parameters*

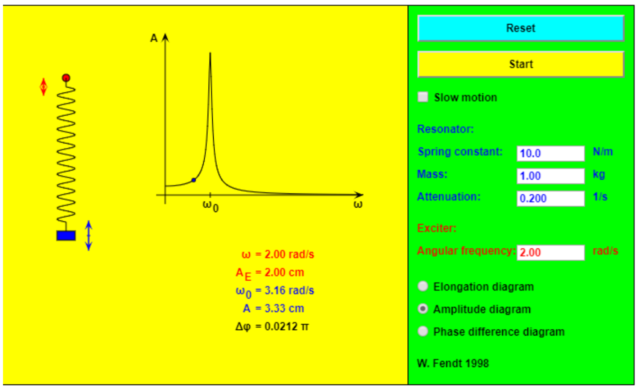
Based on those experiments and lecture notes, answer the following questions:

(ii) *For fixed pendulum parameters and amplitude of excitation, which driving frequency gives you the largest oscillations?*

(iii) *Is there a qualitative difference between the early and late time behaviour of the pendulum? Which?*

(iv) *What happens when the external driving is very slow? Very fast?*

<u>*Solution*</u>*: (ii) When the exciter's frequency agrees with the characteristic*



frequency of the spring pendulum, i.e. resonant frequency ω_0.

(iii) Initial transient. At early time the oscillations are not periodic, while at late time the oscillations are periodic.

(iv) external driving very slow: the pendulum will oscillate nearly synchronously with the exciter and nearly with the same amplitude; external driving very fast: the resonator will oscillate only with a very small amplitude and nearly the opposite phase.

Stage 4 (i) Discuss in your team, then on your table: Where/how do you typically experience black-body radiation? Where have you seen color-changes of the kind discussed in the lecture? In which phenomena do colors appear different from the scheme discussed in the lecture.

(ii) What are the observations in the photo-effect experiment? What would you expect based on what you know?

<u>*Solution*</u>*: (i) Black body example: Sun. Hot stone, heater (mostly IR). Metal cooking plate. Examples of color-changes: light bulb, coil heater. Phenomena where colors appear differently: Chemical Fires, Monatomic vapour (e.g. sodium street light), due to resonance lines. [you will learn details about all these in later semesters].*

(ii) observations from the youtube video experiment: no electrons emitted when red light (low frequency) is shone on the metal; This does not change of

we increase the intensity of the red light; electrons emitted with little velocity when yellow light (a little higher frequency) is shone on the metal; electrons emitted with higher velocity when green light (frequency higher than that of yellow light) is shone on the metal. When we get electrons, their number *(=the current) increases with light intensity, but their kinetic energy stays the same. According to classical electrodynamics, we would expect that electrons be emitted even with red light although with some delay. Also there should be more emission with higher intensity always, and this should also lead to more kinetic energy.*