РОССИЙСКИЙ УНИВЕРСИТЕТ ДРУЖ|БЫ НАРОДОВ

Факультет физико-математических и естественных наук

Кафедра теории вероятностей и кибербезопасности

Лабораторная работа № 5 | Построение графиков

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2. Выполнение задание

2.1 Основные пакеты для работы с графиками в Julia

In [1]:
```
using Pkg
Pkg.add("Plots")
Pkg.add("PyPlot")
Pkg.add("Plotly")
Pkg.add("UnicodePlots")
# подключаем для использования Plots:
using Plots
```

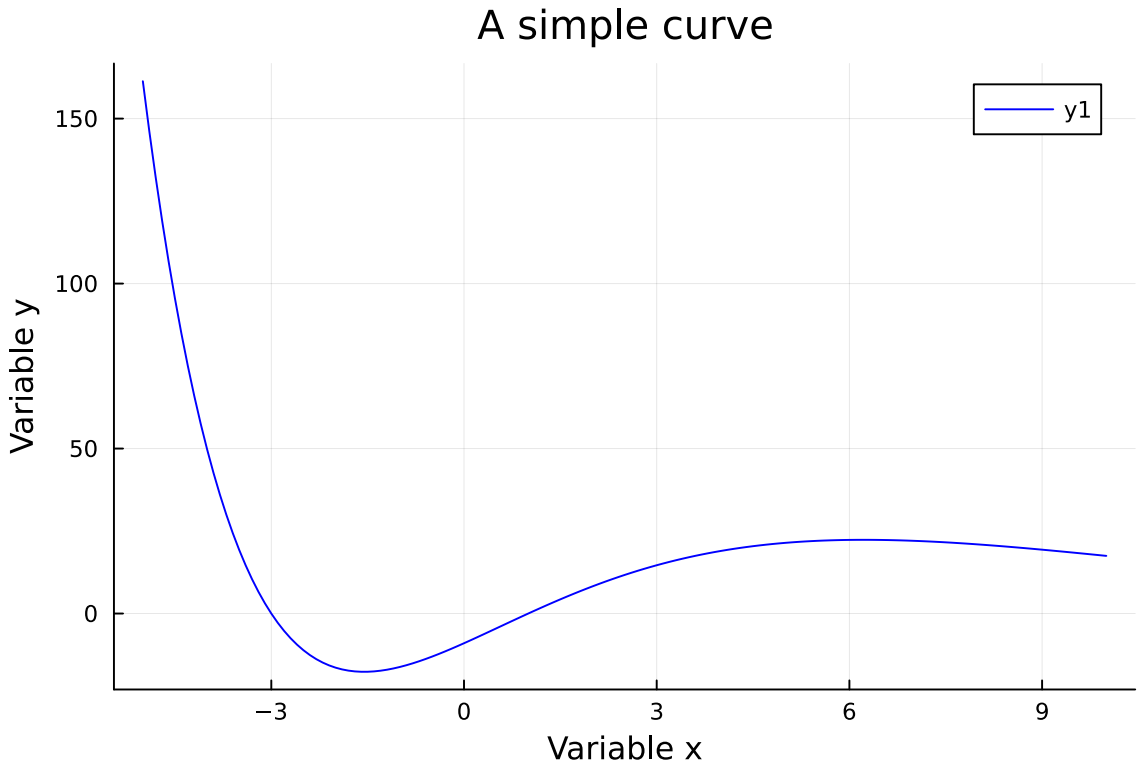
```
  Resolving package versions...
 No Changes to `~/.julia/environments/v1.11/Project.toml`
 No Changes to `~/.julia/environments/v1.11/Manifest.toml`
  Resolving package versions...
 No Changes to `~/.julia/environments/v1.11/Project.toml`
 No Changes to `~/.julia/environments/v1.11/Manifest.toml`
  Resolving package versions...
 No Changes to `~/.julia/environments/v1.11/Project.toml`
 No Changes to `~/.julia/environments/v1.11/Manifest.toml`
  Resolving package versions...
 No Changes to `~/.julia/environments/v1.11/Project.toml`
 No Changes to `~/.julia/environments/v1.11/Manifest.toml`
```

In [2]:
```
# задание функции:
f(x) = (3x.^2 + 6x .- 9).*exp.(-0.3x)

# генерирование массива значений x в диапазоне от -5 до 10 с шагом 0,1
# (шаг задан через указание длины массива):
x = collect(range(-5,10,length=151))
# генерирование массива значений y:
y = f(x)
```

```
# указывается, что для построения графика используется gr():
gr()
# задание опций при построении графика
# (название кривой, подписи по осям, цвет графика):
plot(x,y,
    title="A simple curve",
    xlabel="Variable x",
    ylabel="Variable y",
    color="blue")
```

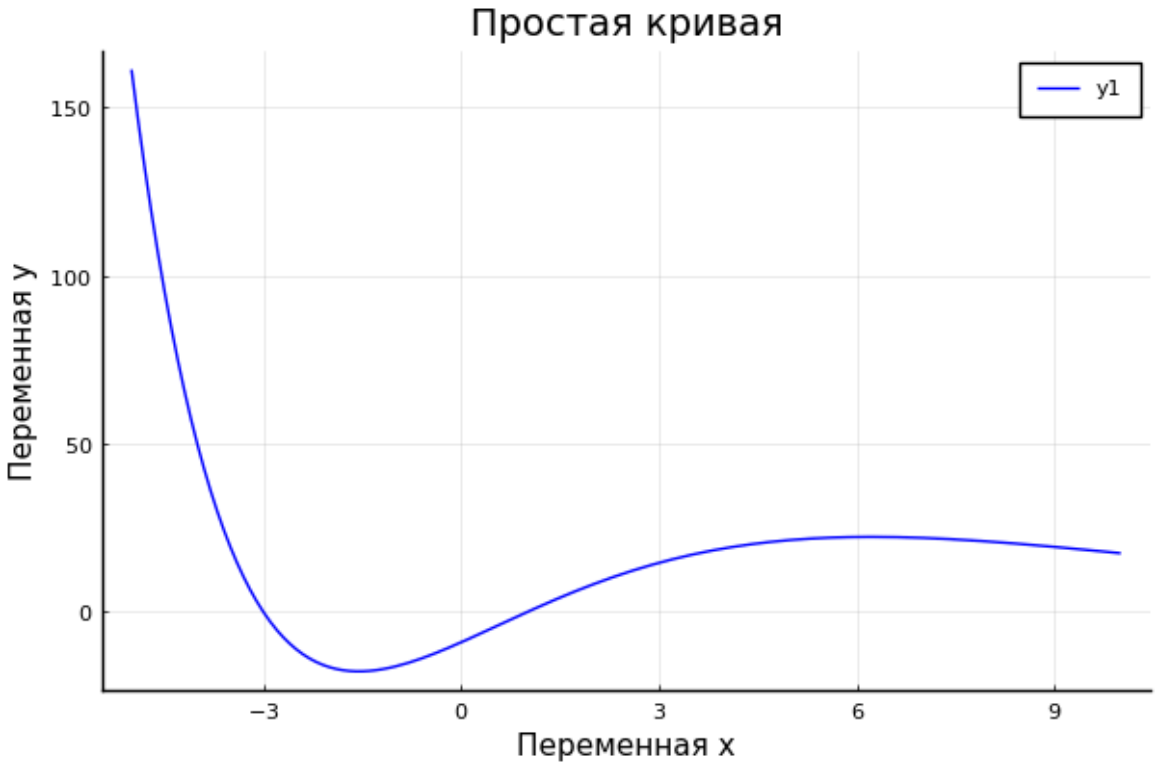
Out[2]:



In [3]:

```
using Plots
# указывается, что для построения графика используется pyplot():
pyplot()
# задание опций при построении графика
# (название кривой, подписи по осям, цвет графика):
plot(x,y,
    title="Простая кривая",
    xlabel="Переменная x",
    ylabel="Переменная y",
    color="blue")
```

Out[3]:



In [67]:

```
using Plots
# указывается, что для построения графика используется plotly():
plotly()
# задание опций при построении графика
# (название кривой, подписи по осям, цвет графика):
plot(x,y,
    title="Простая кривая",
    xlabel="Переменная x",
    ylabel="Переменная y",
    color="blue")

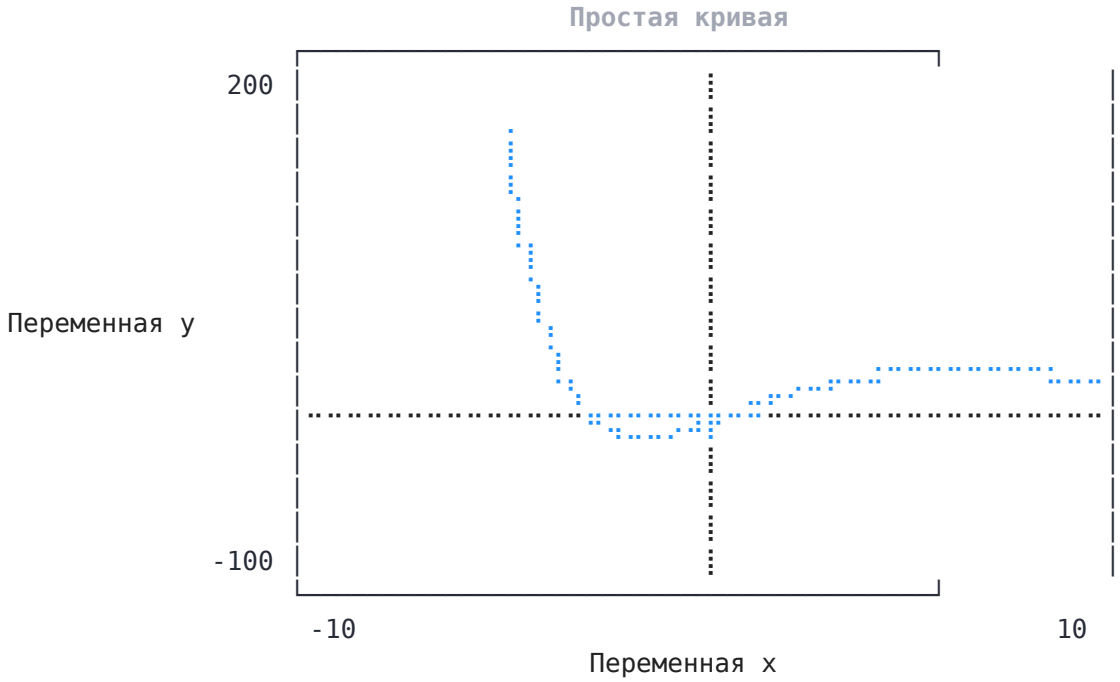
import warnings
warnings.filterwarnings('ignore')
```

```
ArgumentError: Package warnings not found in current path.
- Run `import Pkg; Pkg.add("warnings")` to install the warnings package.

Stacktrace:
 [1] macro expansion
   @ ./loading.jl:2223 [inlined]
 [2] macro expansion
   @ ./lock.jl:273 [inlined]
 [3] __require(into::Module, mod::Symbol)
   @ Base ./loading.jl:2198
 [4] #invoke_in_world#3
   @ ./essentials.jl:1089 [inlined]
 [5] invoke_in_world
   @ ./essentials.jl:1086 [inlined]
 [6] require(into::Module, mod::Symbol)
   @ Base ./loading.jl:2191
```

In [5]:
```
# using Plots
# unicodeplots()
using UnicodePlots #т.к. использование просто в качестве бэкенда не сработал
# задание опций при построении графика
# (название кривой, подписи по осям, цвет графика):
lineplot(x, y,
    title="Простая кривая",
    xlabel="Переменная x",
    ylabel="Переменная y",
    color= :blue)
```

Out[5]:

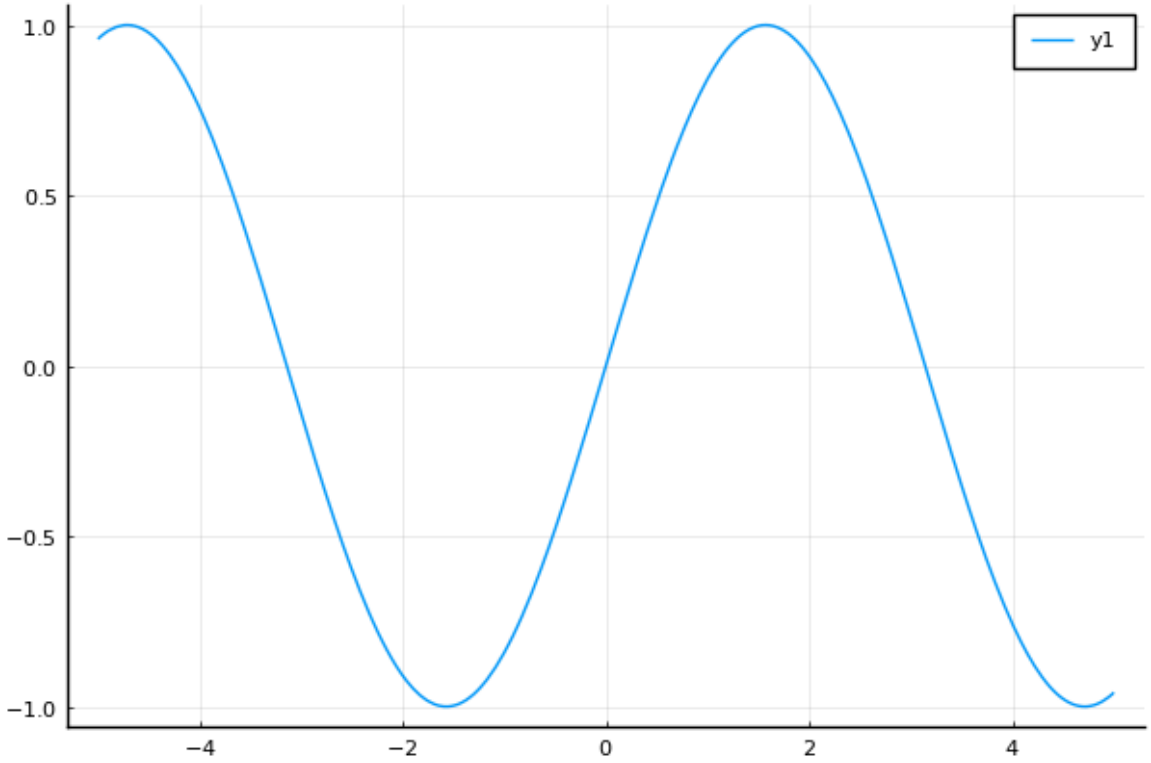


2.2 Опции при построении графика

In [6]:
```
# рассмотрим дополнительные возможности пакетов для работы с графиками
using Plots
# указывается, что для построения графика используется pyplot():
pyplot()
# задание функции sin(x):
sin_theor(x) = sin(x)

# построение графика функции sin(x):
plot(sin_theor)
```

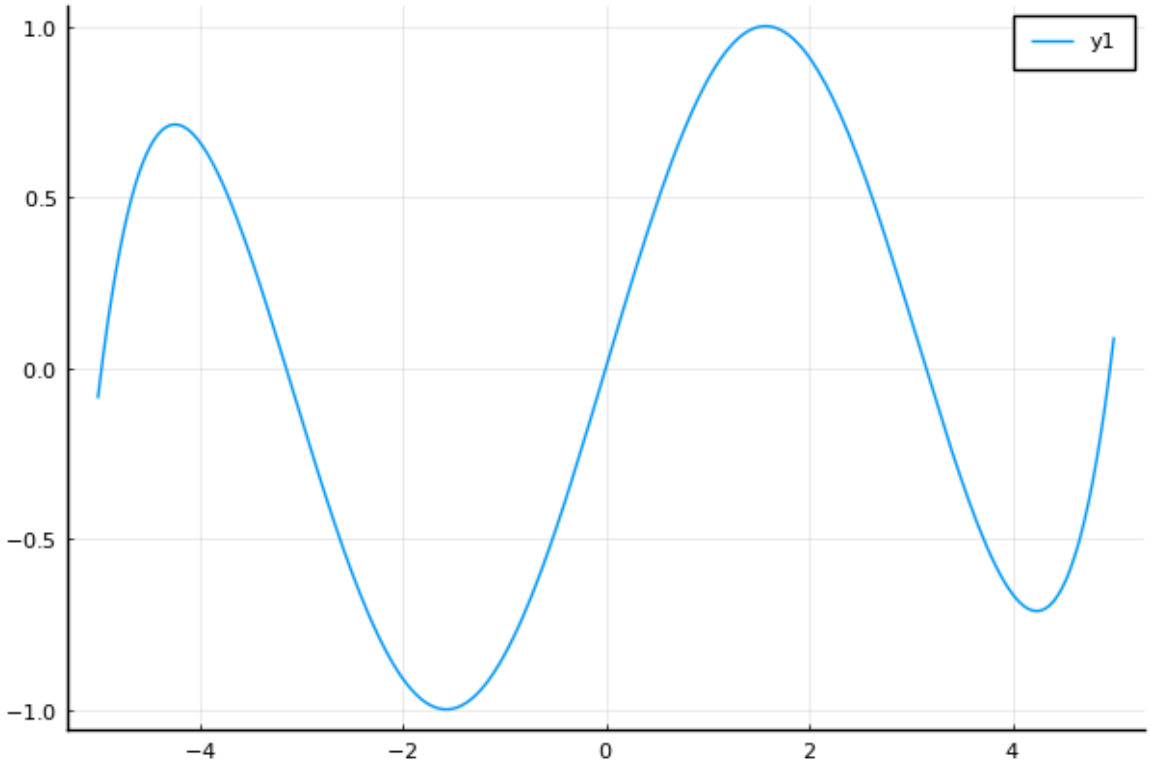
Out[6]:



In [7]:

```
pyplot()
sin_taylor(x) = [(-1)^i*x^(2*i+1)/factorial(2*i+1) for i in 0:4] |> sum
# построение графика функции sin_taylor(x):
plot(sin_taylor)
```

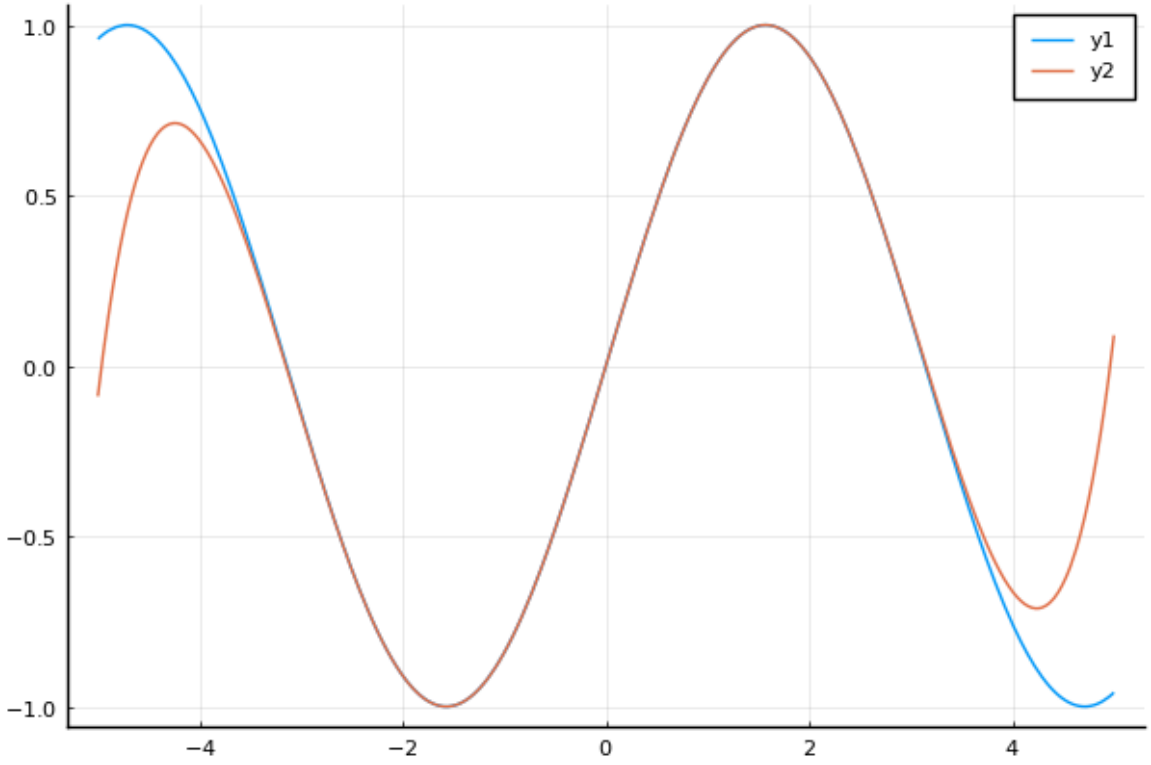
Out[7]:



In [8]:

```
# построение двух функций на одном графике:
plot(sin_theor)
plot!(sin_taylor)
```

Out[8]:

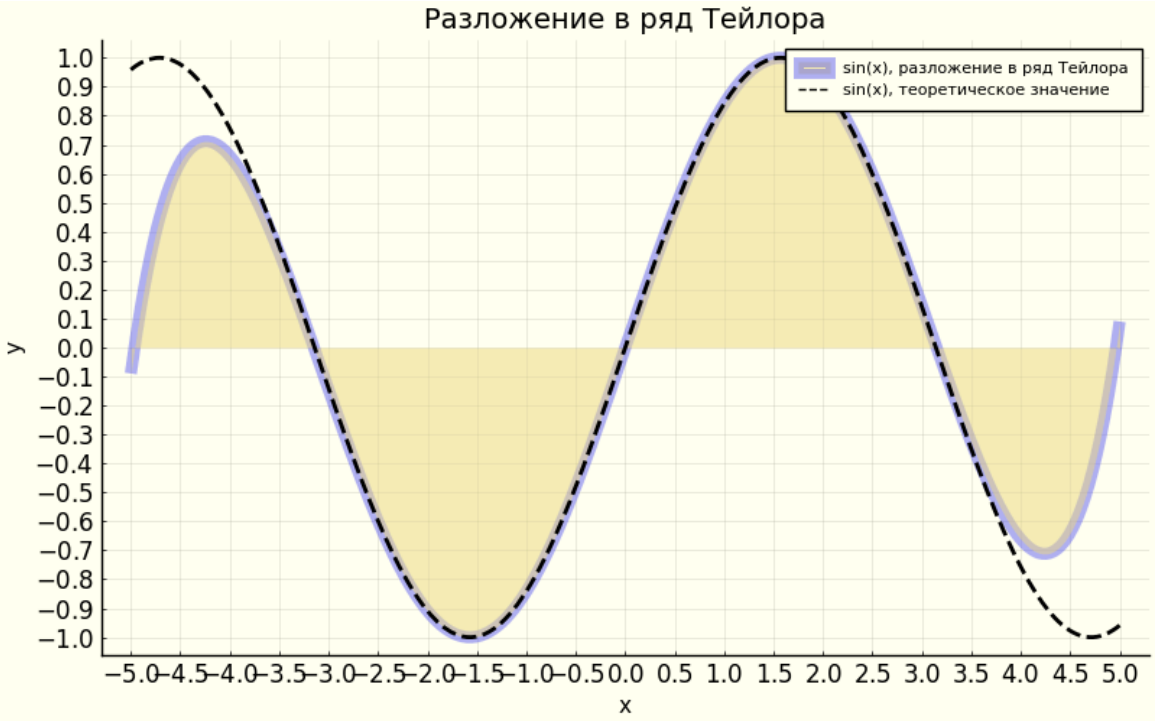


In [9]:

```
plot(
    # функция sin(x):
    sin_taylor,
    # подпись в легенде, цвет и тип линии:
    label = "sin(x), разложение в ряд Тейлора",
    line=(:blue, 0.3, 6, :solid),
    # размер графика:
    size=(800, 500),
    # параметры отображения значений по осям
    xticks = (-5:0.5:5),
    yticks = (-1:0.1:1),
    xtickfont = font(12, "Times New Roman"),
    ytickfont = font(12, "Times New Roman"),
    # подписи по осям:
    ylabel = "y",
    xlabel = "x",
    # название графика:
    title = "Разложение в ряд Тейлора",
    # поворот значений, заданный по оси x:
    xrotation = rad2deg(pi/4),
    # заливка области графика цветом:
    fillrange = 0,
    fillalpha = 0.5,
    fillcolor = :lightgoldenrod,
    # задание цвета фона:
    background_color = :ivory
)
plot!(
    # функция sin_theor:
    sin_theor,
    # подпись в легенде, цвет и тип линии:
    label = "sin(x), теоретическое значение",
```

```
    leg=:topright,
    line=(:black, 1.0, 2, :dash)
)
```

Out[9]:



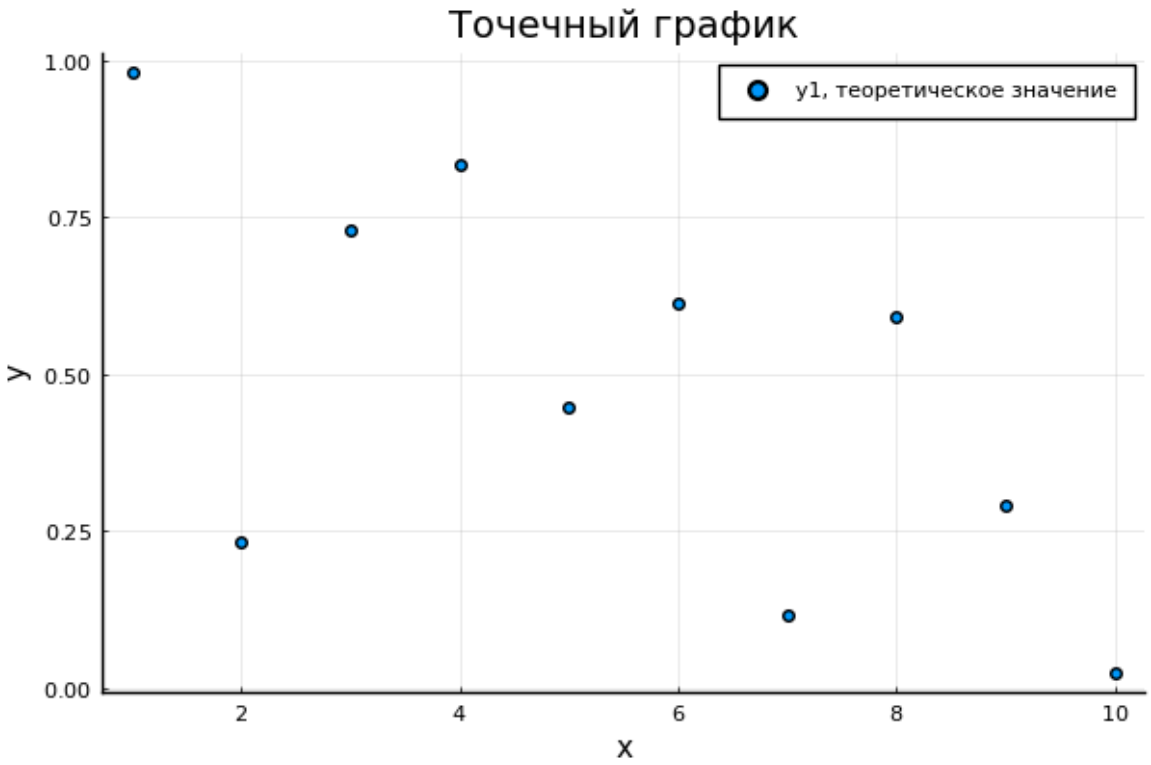

```
findfont: Font family 'Times New Roman' not found.
findfont: Font family ['Times New Roman'] not found. Falling back to DejaVu
Sans.
findfont: Font family 'Times New Roman' not found.
findfont: Font family ['Times New Roman'] not found. Falling back to DejaVu
Sans.
```

2.3 Точечный график

In [10]:

```
# параметры распределения точек на плоскости:
x = range(1,10,length=10)
y = rand(10)
# параметры построения графика:
plot(x, y,
    seriestype = :scatter,
    title = "Точечный график",
    xlabel = "x",
    ylabel = "y",
    # подпись в легенде, цвет и тип линии:
    label = "y1, теоретическое значение",
    leg = :topright
)
```

Out[10]:




```
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
```

In [11]:

```
# параметры распределения точек на плоскости:
n = 50
x = rand(n)
y = rand(n)
ms = rand(50) * 30
# параметры построения графика:
scatter(x, y,
    markersize=ms,
    # подписи по осям:
    xlabel = "x",
    ylabel = "y",
    # подпись в легенде, цвет и тип линии:
    label = "y1, теоретическое значение",
    title = "Точечный график")
```

Out[11]:

```
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
```

In [12]:

```
# параметры распределения точек в пространстве:
n = 50
x = rand(n)
y = rand(n)
z = rand(n)
ms = rand(50) * 30
# параметры построения графика:
scatter(x, y, z,
    markersize=ms,
    xlabel = "x",
    ylabel = "y",
    zlabel = "z",
    # подпись в легенде, цвет и тип линии:
    label = "sin(x), теоретическое значение",
    title = "Точечный график")
```

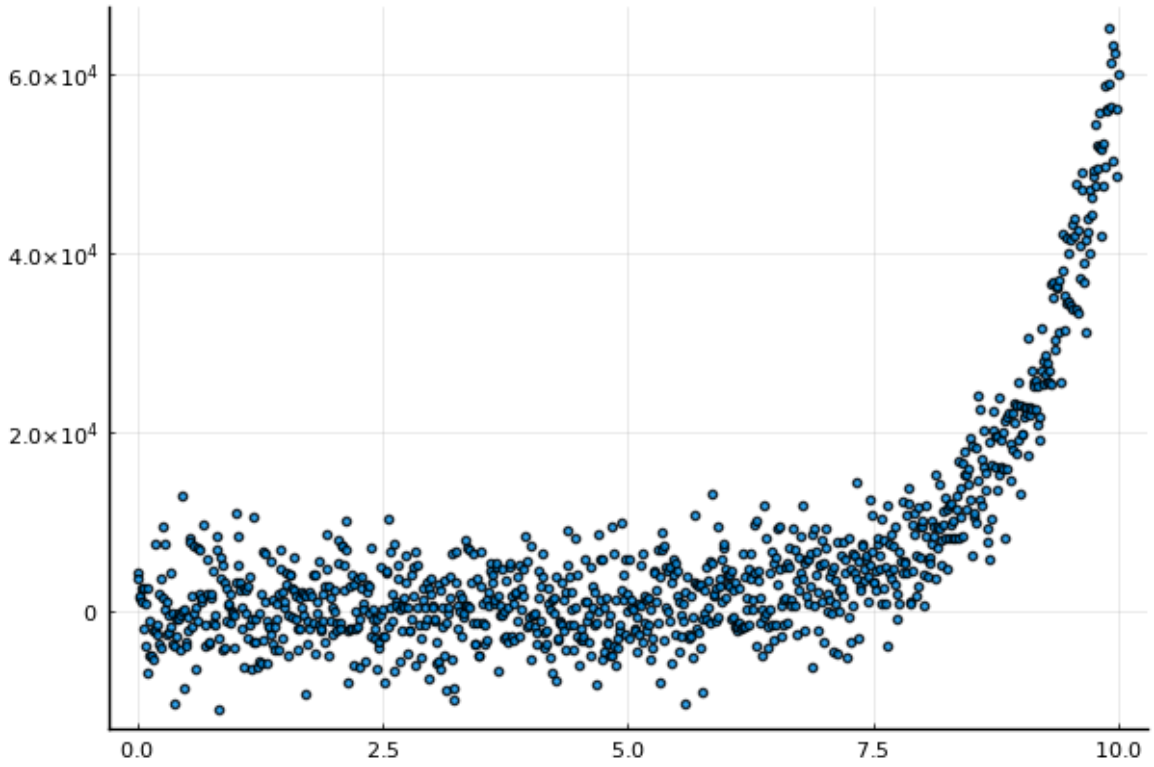
Out[12]:

```
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
```

In [13]:

```
# массив данных от 0 до 10 с шагом 0.01:
x = collect(0:0.01:9.99)
# экспоненциальная функция со случайным сдвигом значений:
y = exp.(ones(1000)+x) + 4000*randn(1000)
# построение графика:
scatter(x,y,markersize=3,alpha=.8,legend=false)
```

Out[13]:



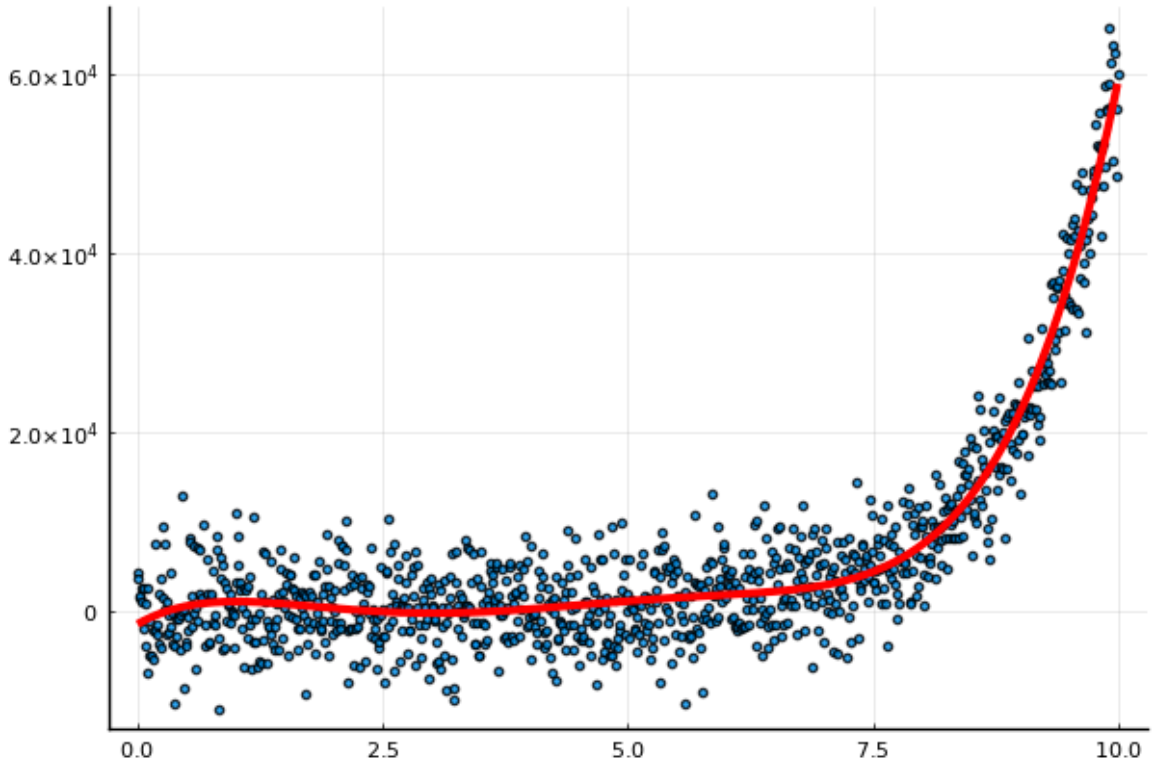

```
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
```

In [14]:

```
# определение массива для нахождения коэффициентов полинома:
A = [ones(1000) x x.^2 x.^3 x.^4 x.^5]
# решение матричного уравнения:
c = A\y
# построение полинома:
f1 = c[1]*ones(1000) + c[2]*x + c[3]*x.^2 + c[4]*x.^3 + c[5]*x.^4 + c[6]*x.^

# построение графика аппроксимирующей функции:
plot!(x, f1, linewidth=3, color=:red)
```

Out[14]:

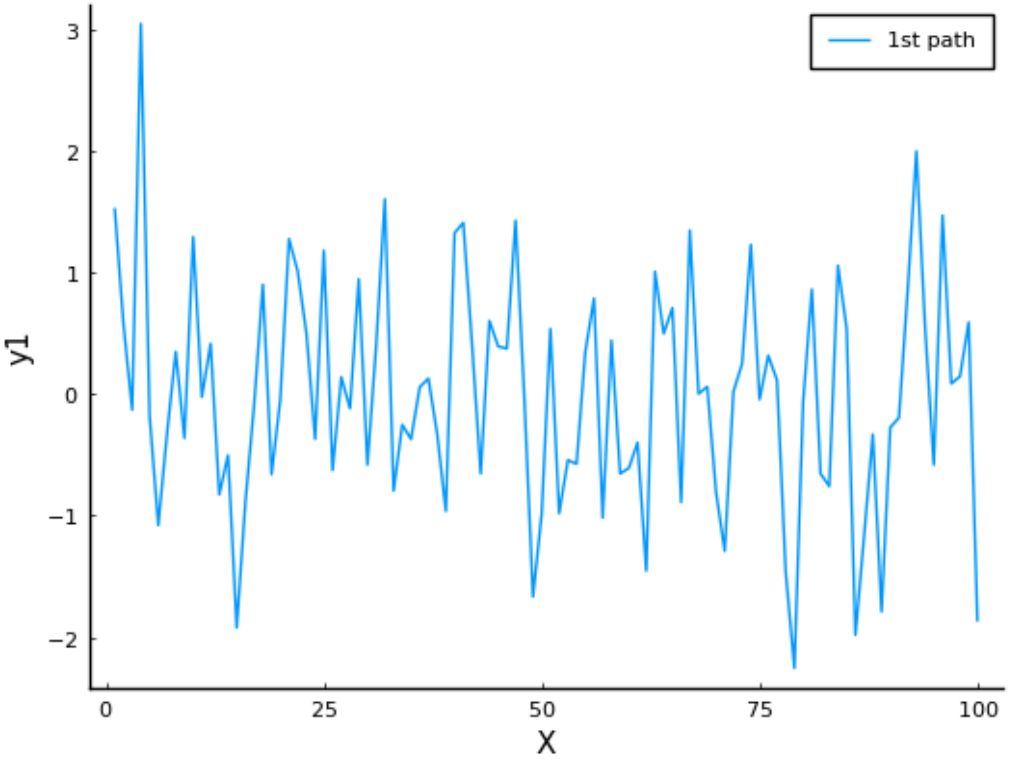



```
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
```

In [15]:

```
using Plots.PlotMeasures
# пример случайной траектории
# (заданы обозначение траектории, легенда вверху справа, без сетки)
plot(randn(100),
    xlabel = "X",
    ylabel="y1",
    label = "1st path",
    leg=:topright,
    grid = :off,
    right_margin = 20mm
)
```

Out[15]:



In [16]:

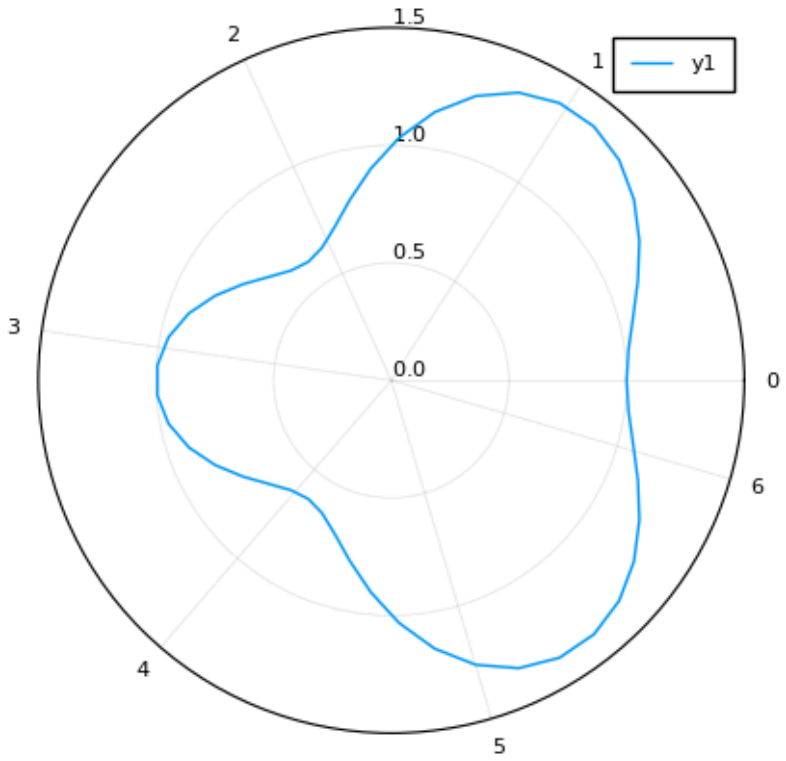
```
# пример добавления на график второй случайной траектории
# (задано обозначение траектории и её цвет, легенда снизу справа, без сетки)
# задана рамка графика
plot!(twinx(), randn(100)*10,
    c=:red,
    ylabel="y2",
    label = "2nd path",
    leg=:bottomright,
    grid = :off,
    box = :on,
    size=(600, 400)
)
```

Out[16]:

In [17]:

```
# функция в полярных координатах:
r(θ) = 1 + cos(θ) * sin(θ)^2
# полярная система координат:
θ = range(0, stop=2π, length=50)
# график функции, заданной в полярных координатах:
plot(θ, r.(θ),
    proj=:polar,
    lims=(0,1.5)
)
```

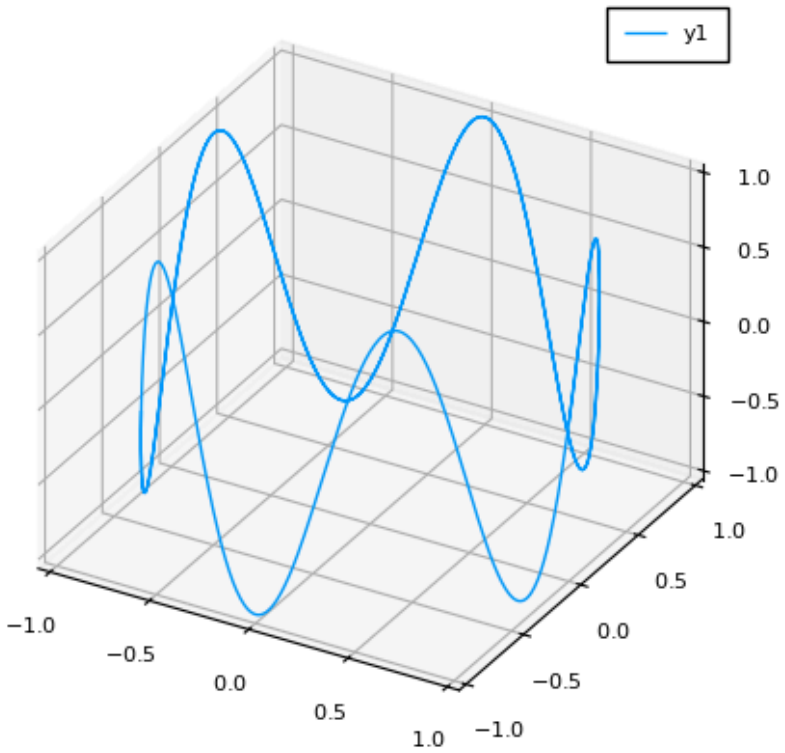
Out[17]:



In [18]:

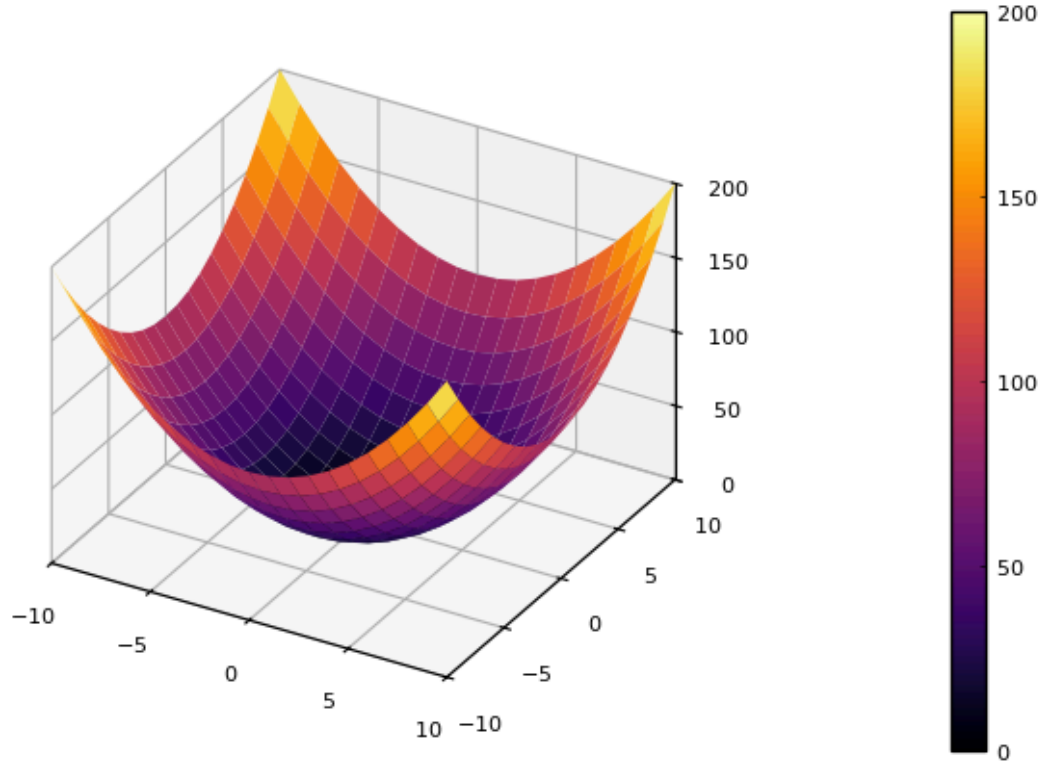
```
# параметрическое уравнение
t = range(0, stop=10, length=1000)
x = cos.(t)
y = sin.(t)
z = sin.(5t)
# построение графика:
plot(x, y, z)
```

Out[18]:



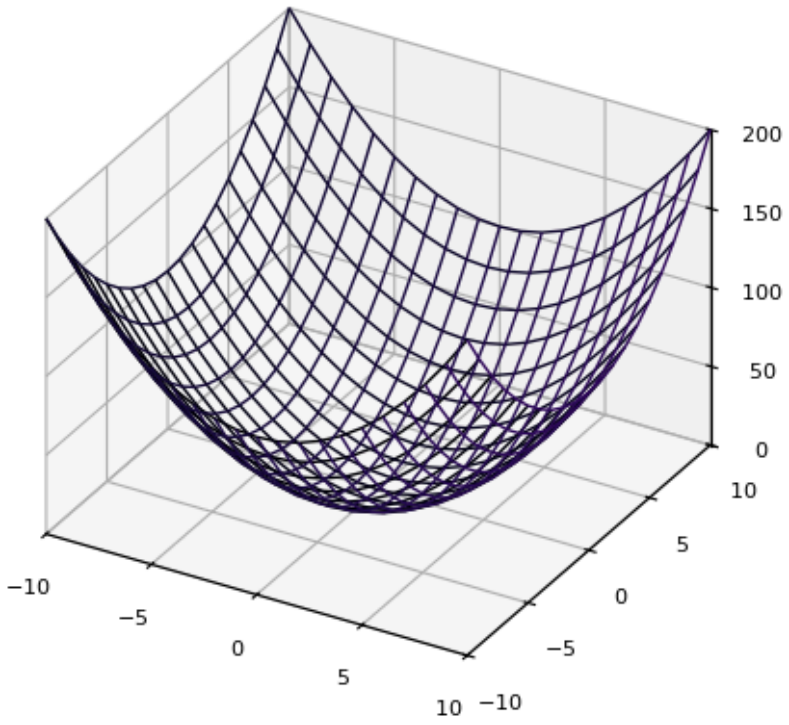
In [19]:
```
# построение графика поверхности:
f(x,y) = x^2 + y^2
x = -10:10
y = x
surface(x, y, f)
```

Out[19]:



In [20]:
```
# построение графика поверхности:
f(x,y) = x^2 + y^2
x = -10:10
y = x
plot(x, y, f,
    linetype=:wireframe
)
```

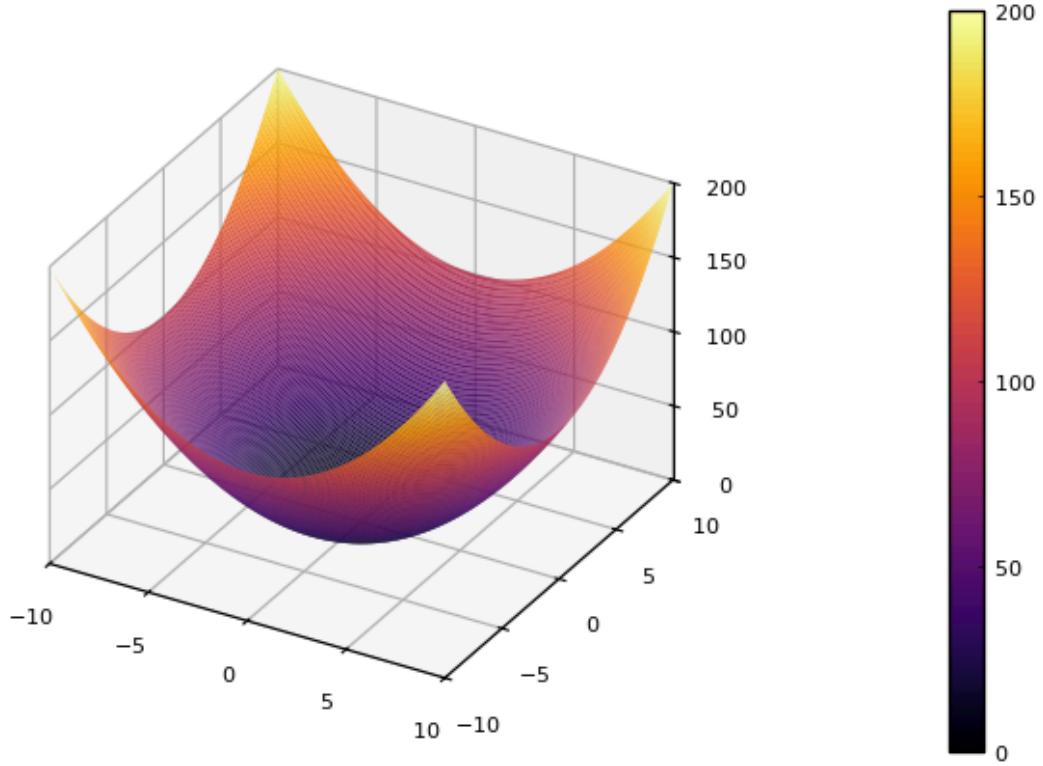
Out[20]:



In [21]:

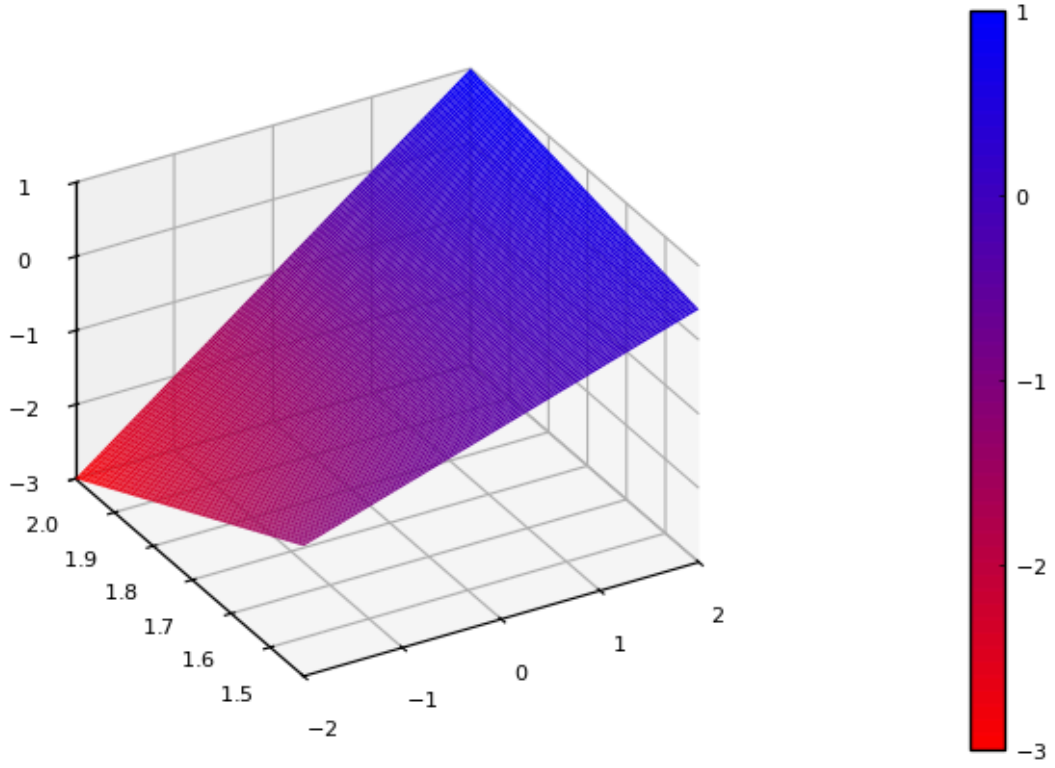
```
f2(x,y) = x^2 + y^2
x = -10:0.1:10
y = x
plot(x, y, f2,
linetype = :surface
)
```

Out[21]:



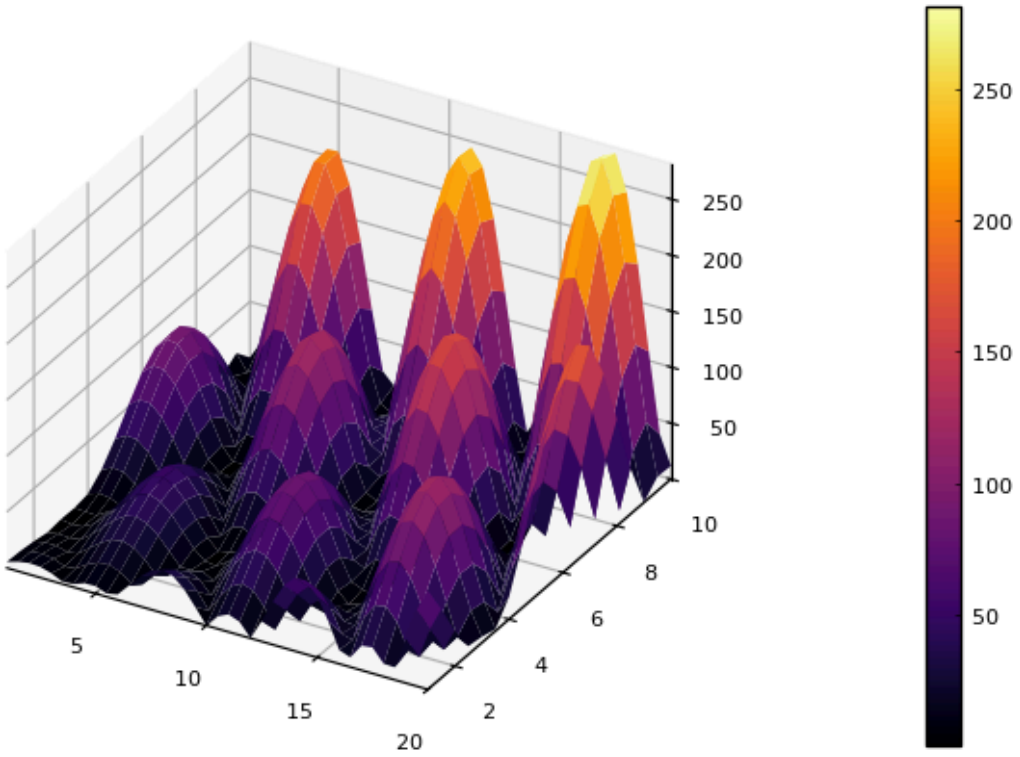
In [22]:
```
x = range(-2,stop=2,length=100)
y = range(sqrt(2),stop=2,length=100)
f3(x,y) = x*y-x-y+1
plot(x, y, f3,
    linetype = :surface,
    c=cgrad([:red,:blue]),
    camera=(-30,30),
)
```

Out[22]:



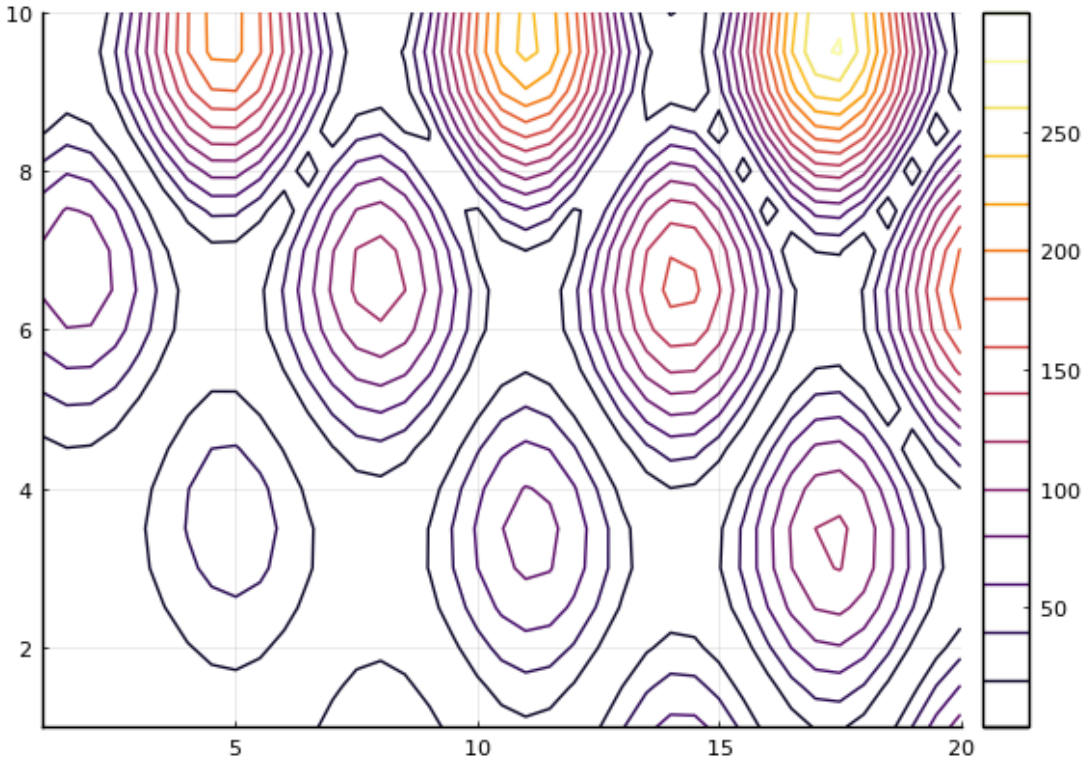
In [23]:
```
x = 1:0.5:20
y = 1:0.5:10
g(x, y) = (3x + y ^ 2) * abs(sin(x) + cos(y))
plot(x, y, g,
    linetype = :surface,
)
```

Out[23]:



In [24]:
```
contour(x, y, g)
```

Out[24]:

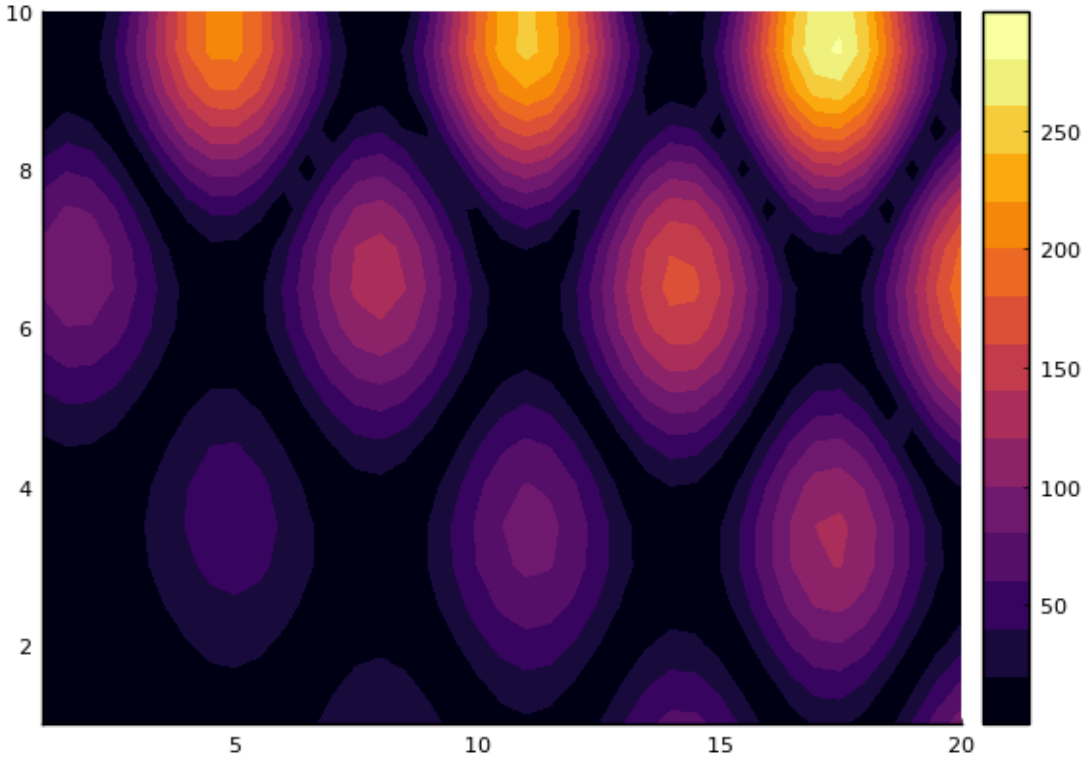



```
sys:1: UserWarning: The following kwargs were not used by contour: 'label'
sys:1: UserWarning: The following kwargs were not used by contour: 'label'
sys:1: UserWarning: The following kwargs were not used by contour: 'label'
sys:1: UserWarning: The following kwargs were not used by contour: 'label'
```

In [25]:
```
p = contour(x, y, g,
fill=true)
```

```
plot(p)
```

Out[25]:

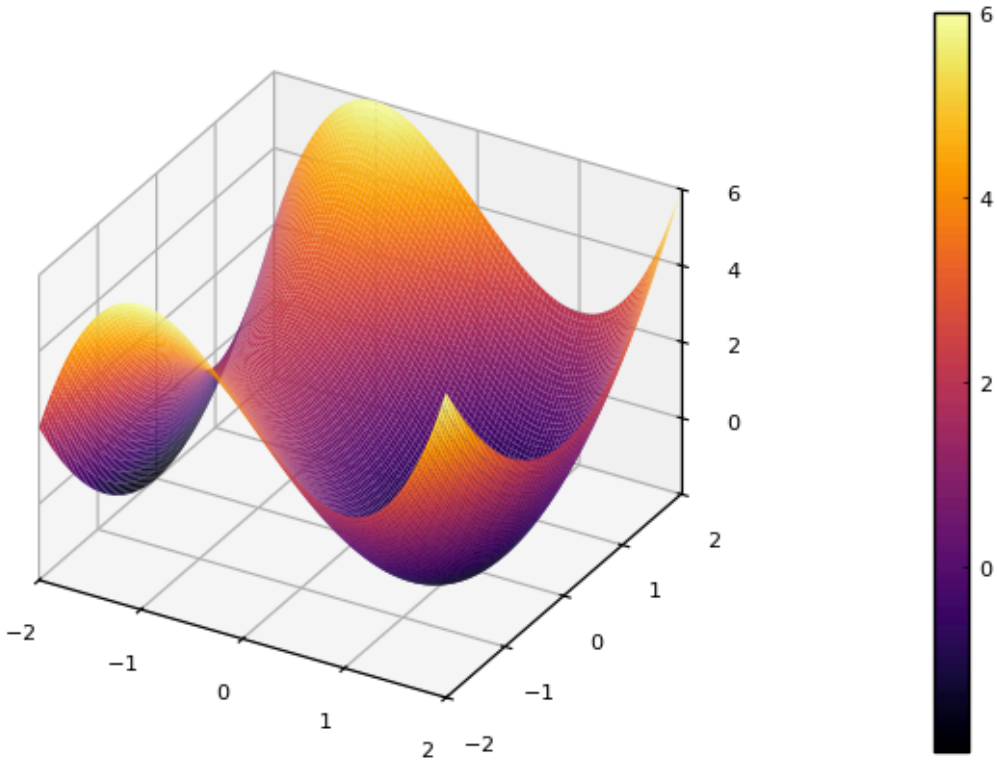



```
sys:1: UserWarning: The following kwargs were not used by contour: 'label'
sys:1: UserWarning: The following kwargs were not used by contour: 'label'
sys:1: UserWarning: The following kwargs were not used by contour: 'label'
sys:1: UserWarning: The following kwargs were not used by contour: 'label'
```

In [26]:

```
# определение переменных:
X0 = range(-2, stop=2, length=100)
Y0 = range(-2, stop=2, length=100)
# определение функции:
h(x, y) = x^3 - 3x + y^2
# построение поверхности:
plot(X0, Y0, h,
    linetype = :surface
)
```

Out[26]:



In [27]:
```
# градиент:
xs = range(-2, stop=2, length=12)
ys = range(-2, stop=2, length=12)
```

Out[27]:
```
-2.0:0.36363636363636365:2.0
```

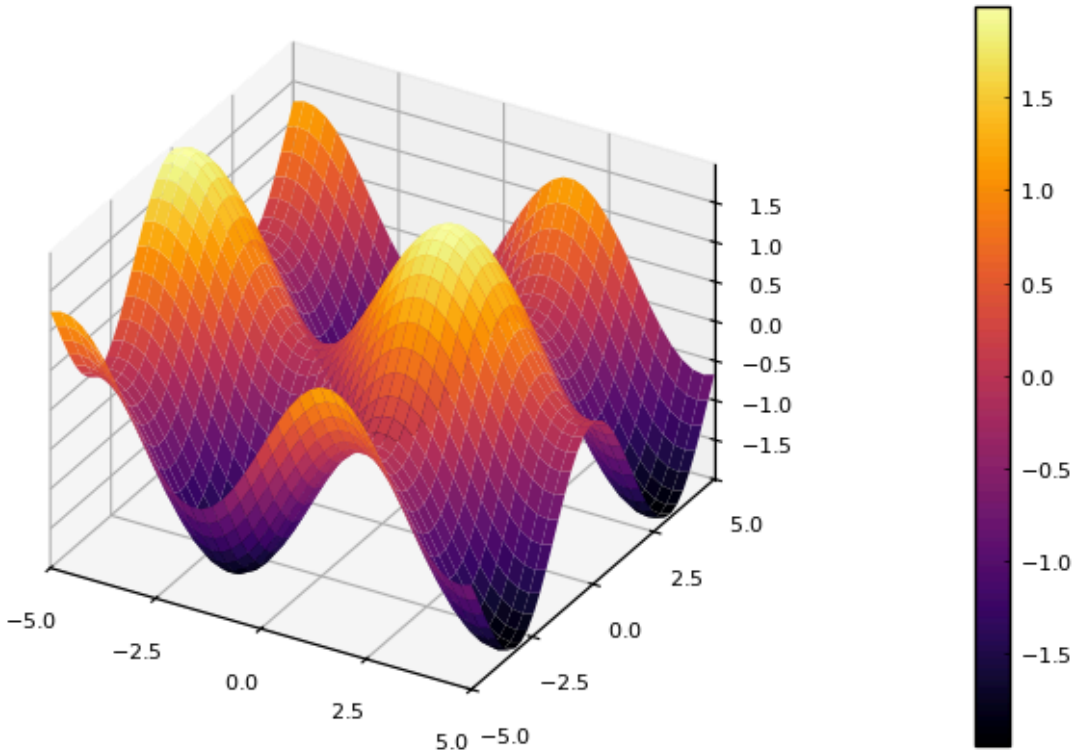
In [28]:
```
# производная от исходной функции:
dh(x, y) = [3x^2-3; 2y]/25
```

Out[28]:
```
dh (generic function with 1 method)
```

2.4 Анимация

In [29]:
```
pyplot()
# построение поверхности:
i = 0
X = Y = range(-5,stop=5,length=40)
surface(X, Y, (x,y) -> sin(x+10sin(i))+cos(y))
```

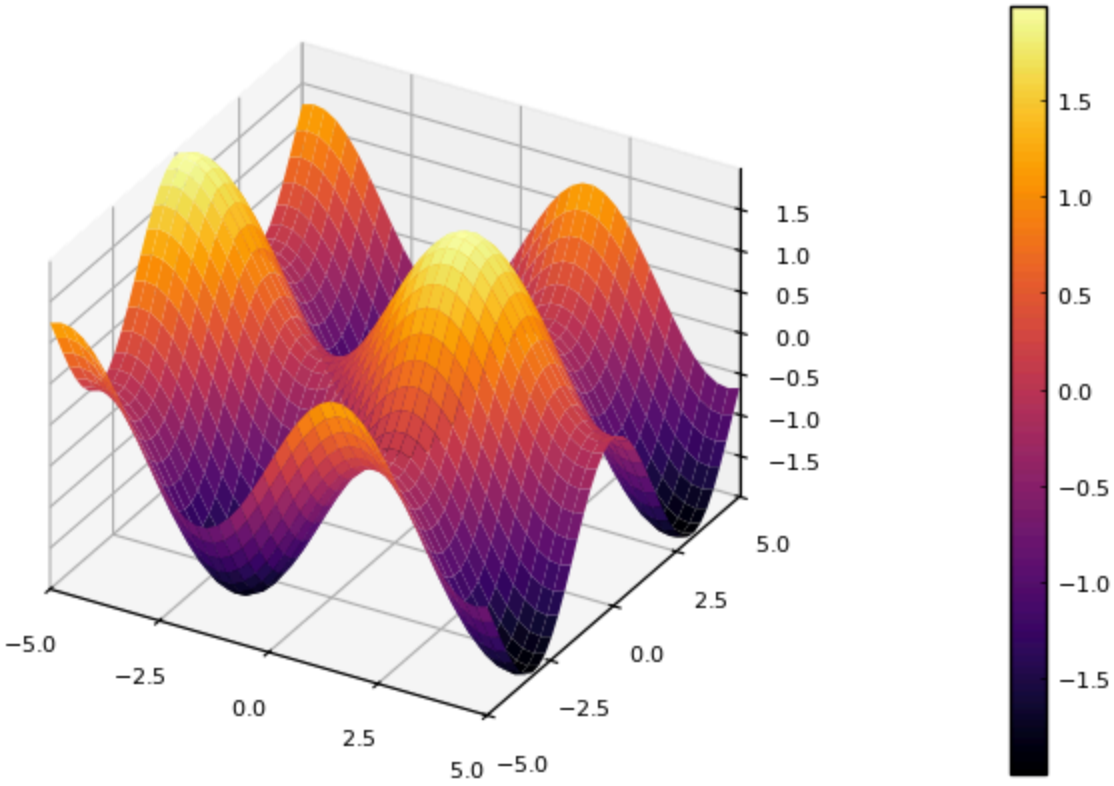
Out[29]:



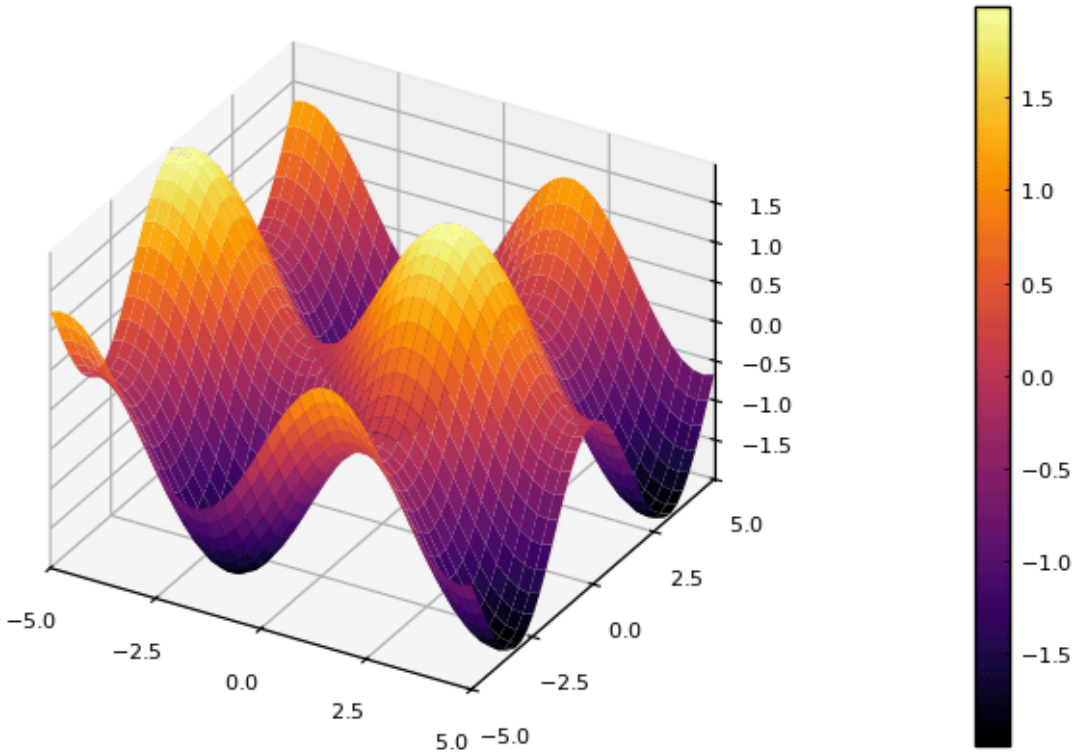
In [30]:

```
# анимация:
X = Y = range(-5, stop=5, length=40)
@gif for i in range(0, stop=2π, length=100)
surface(X, Y, (x, y) -> sin(x + 10sin(i)) + cos(y))
end
```

```
[ Info: Saved animation to /home/maabedelhay/jupyter/Julia/lab05/tmp.gif
```



Out[30]:

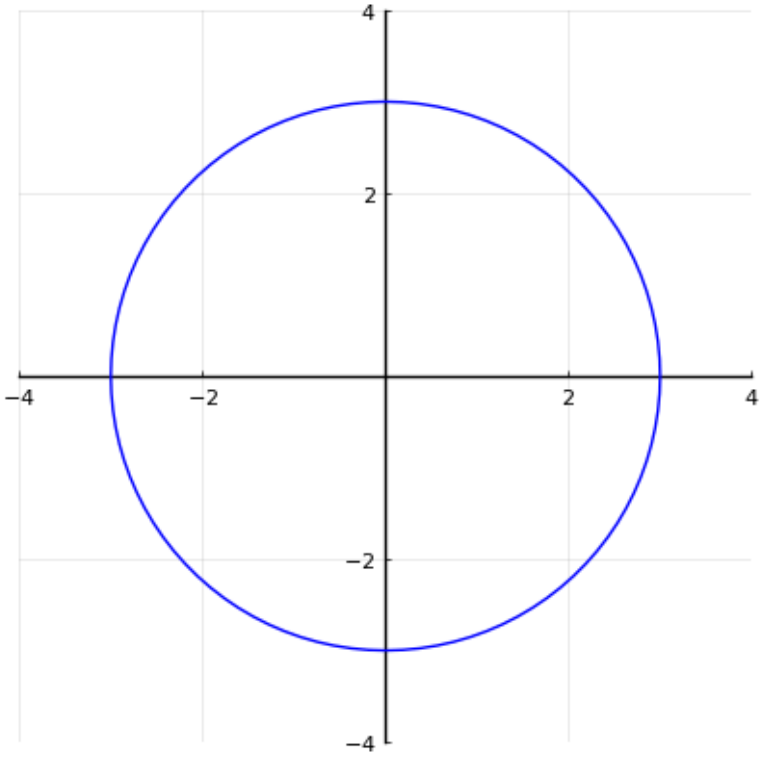


2.5 Гипоциклоида

In [31]:

```
# радиус малой окружности:
r1 = 1
# коэффициент для построения большой окружности:
k = 3
# число отсчётов:
n = 100
# массив значений угла θ:
# theta from 0 to 2pi ( + a little extra)
θ = collect(0:2*π/100:2*π+2*π/100)
# массивы значений координат:
X = r1*k*cos.(θ)
Y = r1*k*sin.(θ)
# задаём оси координат:
plt = plot(5, xlim=(-4,4), ylim=(-4,4), c=:red, aspect_ratio=1, legend=false
# большая окружность:
plot!(plt, X,Y, c=:blue, legend=false)
```

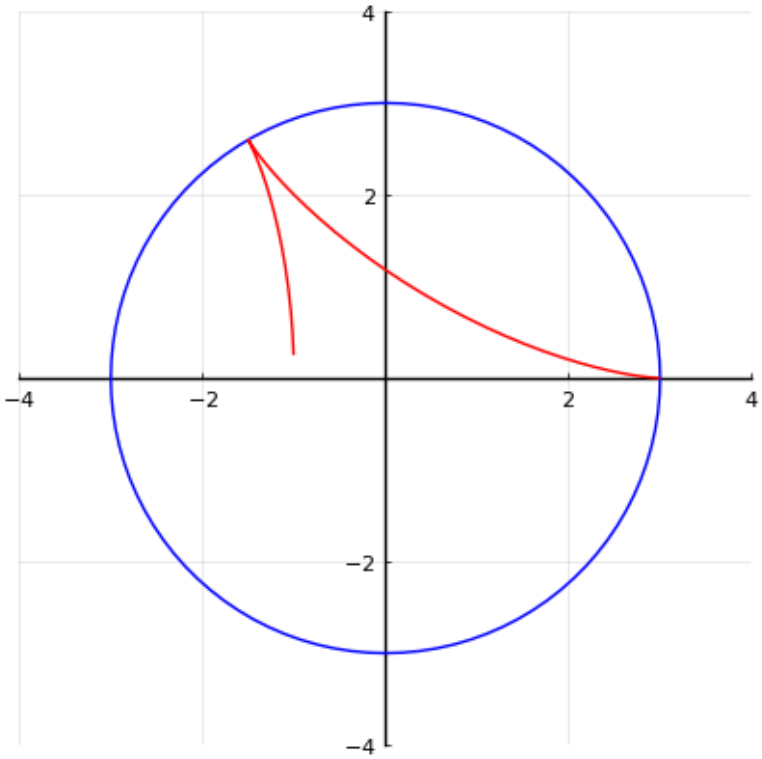
Out[31]:



In [32]:

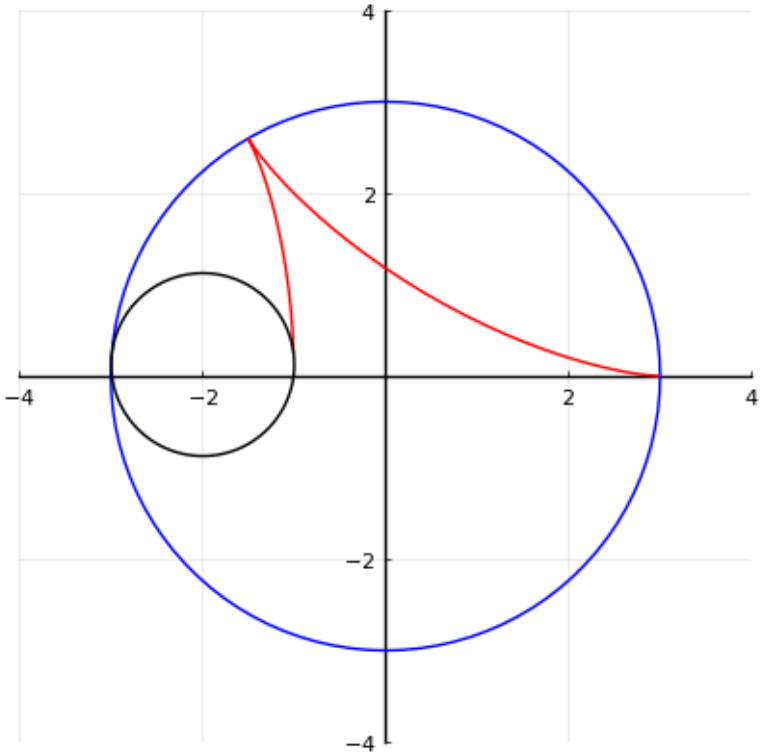
```
i = 50
t = θ[1:i]
# гипоциклоида:
x = r1*(k-1)*cos.(t) + r1*cos.((k-1)*t)
y = r1*(k-1)*sin.(t) - r1*sin.((k-1)*t)
plot!(x,y, c=:red)
```

Out[32]:



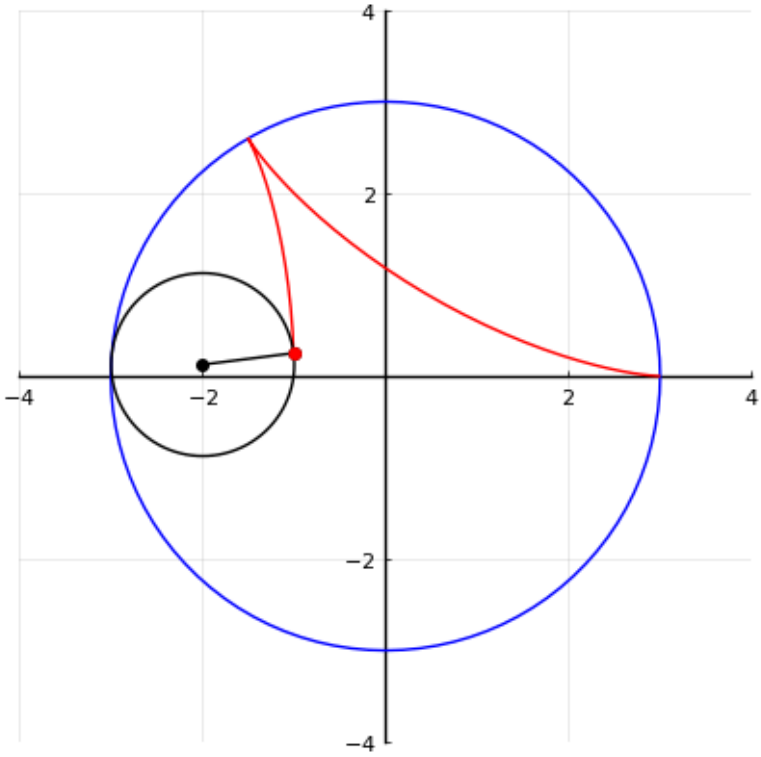
In [33]:
```
# малая окружность:
xc = r1*(k-1)*cos(t[end]) .+ r1*cos.(θ)
yc = r1*(k-1)*sin(t[end]) .+ r1*sin.(θ)
plot!(xc,yc,c=:black)
```

Out[33]:



In [34]:
```
# радиус малой окружности:
xl = transpose([r1*(k-1)*cos(t[end]) x[end]])
yl = transpose([r1*(k-1)*sin(t[end]) y[end]])
plot!(xl, yl, markershape=:circle, markersize=4, c=:black)
scatter!([x[end]], [y[end]], c=:red, markerstrokecolor=:red)
```

Out[34]:




```
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
```

In [71]:

```
anim = @animate for i in 1:n
    # задаём оси координат:
    plt=plot(5, xlim=(-4,4), ylim=(-4,4), c=:red, aspect_ratio=1, legend=fal
    # большая окружность:
    plot!(plt, X, Y, c=:blue, legend=false)
    t = θ[1:i]

    # гипоциклоида:
    x = r1*(k-1)*cos.(t) + r1*cos.((k-1)*t)
    y = r1*(k-1)*sin.(t) - r1*sin.((k-1)*t)
    plot!(x,y, c=:red)

    # малая окружность:
    xc = r1*(k-1)*cos(t[end]) .+ r1*cos.(θ)
    yc = r1*(k-1)*sin(t[end]) .+ r1*sin.(θ)
    plot!(xc, yc, c=:black)

    # радиус малой окружности:
    xl = transpose([r1*(k-1)*cos(t[end]) x[end]])
    yl = transpose([r1*(k-1)*sin(t[end]) y[end]])
    plot!(xl,yl,markershape=:circle, markersize=4, c=:black)
    scatter!([x[end]], [y[end]], c=:red, markerstrokecolor=:red)
    end
```

```
    gif(anim,"hypocycloid.gif")
```

```
MethodError: no method matching _show(::IOStream, ::MIME{Symbol("image/pn
g")}, ::Plots.Plot{Plots.PlotlyBackend})
The function `_show` exists, but no method is defined for this combination o
f argument types.

Tip: For saving/rendering as png with the `Plotly` backend `PlotlyBase` and
`PlotlyKaleido` need to be installed.


Closest candidates are:
  _show(::IO, ::MIME{Symbol("image/png")}, ::Plots.Plot{Plots.PyPlotBacken
d})
   @ Plots ~/.julia/packages/Plots/Ec1L1/src/backends/deprecated/pyplot.jl:1
624
  _show(::IO, ::MIME{Symbol("image/png")}, ::Plots.Plot{Plots.GRBackend})
   @ Plots ~/.julia/packages/Plots/Ec1L1/src/backends/gr.jl:2075
  _show(::IO, ::MIME{Symbol("text/html")}, ::Plots.Plot{Plots.PlotlyBacken
d})
   @ Plots ~/.julia/packages/Plots/Ec1L1/src/backends/plotly.jl:1134
  ...


Stacktrace:
  [1] #invokelatest#2
    @ ./essentials.jl:1055 [inlined]
  [2] invokelatest
    @ ./essentials.jl:1052 [inlined]
  [3] show
    @ ~/.julia/packages/Plots/Ec1L1/src/output.jl:232 [inlined]
  [4] #346
    @ ~/.julia/packages/Plots/Ec1L1/src/output.jl:6 [inlined]
  [5] open(::Plots.var"#346#347"{Plots.Plot{Plots.PlotlyBackend}}, ::String,
::Vararg{String}; kwargs::@Kwargs{})
    @ Base ./io.jl:410
  [6] open
    @ ./io.jl:407 [inlined]
  [7] png
    @ ~/.julia/packages/Plots/Ec1L1/src/output.jl:6 [inlined]
  [8] frame(anim::Animation, plt::Plots.Plot{Plots.PlotlyBackend})
    @ Plots ~/.julia/packages/Plots/Ec1L1/src/animation.jl:26
  [9] frame(anim::Animation)
    @ Plots ~/.julia/packages/Plots/Ec1L1/src/animation.jl:24
 [10] macro expansion
    @ ~/.julia/packages/Plots/Ec1L1/src/animation.jl:232 [inlined]
 [11] macro expansion
    @ ./In[71]:24 [inlined]
 [12] top-level scope
    @ ~/.julia/packages/Plots/Ec1L1/src/animation.jl:251
```

2.6 Использование пакета Distributions

In [75]:
```
import Pkg
Pkg.add("Distributions")
using Distributions
```

```
  Resolving package versions...
 No Changes to `~/.julia/environments/v1.11/Project.toml`
 No Changes to `~/.julia/environments/v1.11/Manifest.toml`
```

In [76]:
```
pyplot()
ages = rand(15:55, 1000)
histogram(ages)
```

```
UndefVarError: `histogram` not defined in `Main`
Hint: It looks like two or more modules export different bindings with this
name, resulting in ambiguity. Try explicitly importing it from a particular
module, or qualifying the name with the module it should come from.
Hint: a global variable of this name also exists in Plots.
Hint: a global variable of this name also exists in UnicodePlots.

Stacktrace:
 [1] top-level scope
   @ In[76]:3
```

In [38]:
```
d = Normal(35.0, 10.0)
ages = rand(d, 1000)
histogram(
    ages,
    label="Распределение по возрастам (года)",
    xlabel = "Возраст (лет)",
    ylabel= "Количество"
)
```

```
UndefVarError: `histogram` not defined in `Main`
Hint: It looks like two or more modules export different bindings with this
name, resulting in ambiguity. Try explicitly importing it from a particular
module, or qualifying the name with the module it should come from.
Hint: a global variable of this name also exists in Plots.
Hint: a global variable of this name also exists in UnicodePlots.

Stacktrace:
 [1] top-level scope
   @ In[38]:3
```

In [39]:
```
plotly()
d1=Normal(10.0,5.0);
d2=Normal(35.0,10.0);
d3=Normal(60.0,5.0);
N=1000;
ages = (Float64)[];
ages = append!(ages,rand(d1,Int64(ceil(N/2))));
ages = append!(ages,rand(d2,N));
ages = append!(ages,rand(d3,Int64(ceil(N/3))));
histogram(
    ages,
    bins=50,
    label="Распределение по возрастам (года)",
```

```
    xlabel = "Возраст (лет)",
    ylabel= "Количество",
    title = "Распределение по возрастам (года)"
)
```

```
UndefVarError: `histogram` not defined in `Main`
Hint: It looks like two or more modules export different bindings with this
name, resulting in ambiguity. Try explicitly importing it from a particular
module, or qualifying the name with the module it should come from.
Hint: a global variable of this name also exists in Plots.
Hint: a global variable of this name also exists in UnicodePlots.

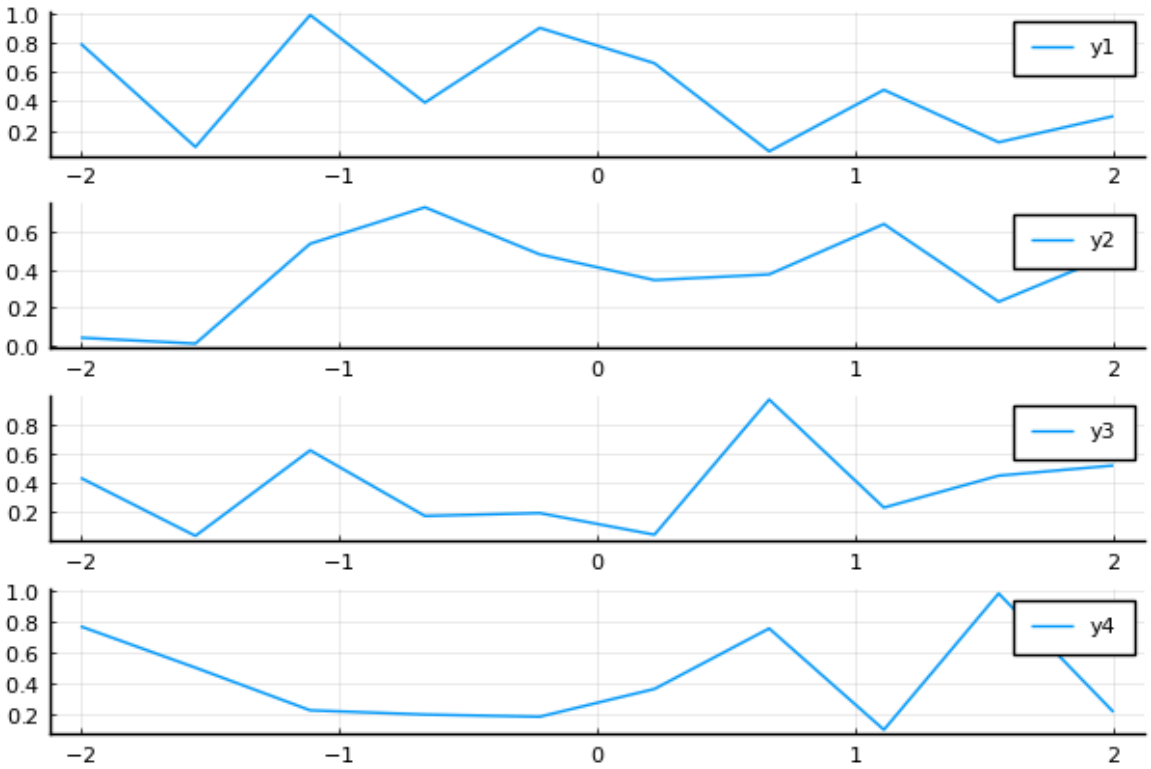
Stacktrace:
 [1] top-level scope
   @ In[39]:10
```

In [ ]:

5.2.14. Подграфики

In [40]:
```
# подгружаем pyplot():
pyplot()
# построение серии графиков:
x=range(-2,2,length=10)
y = rand(10,4)
plot(x,y,
    layout=(4,1)
)
```

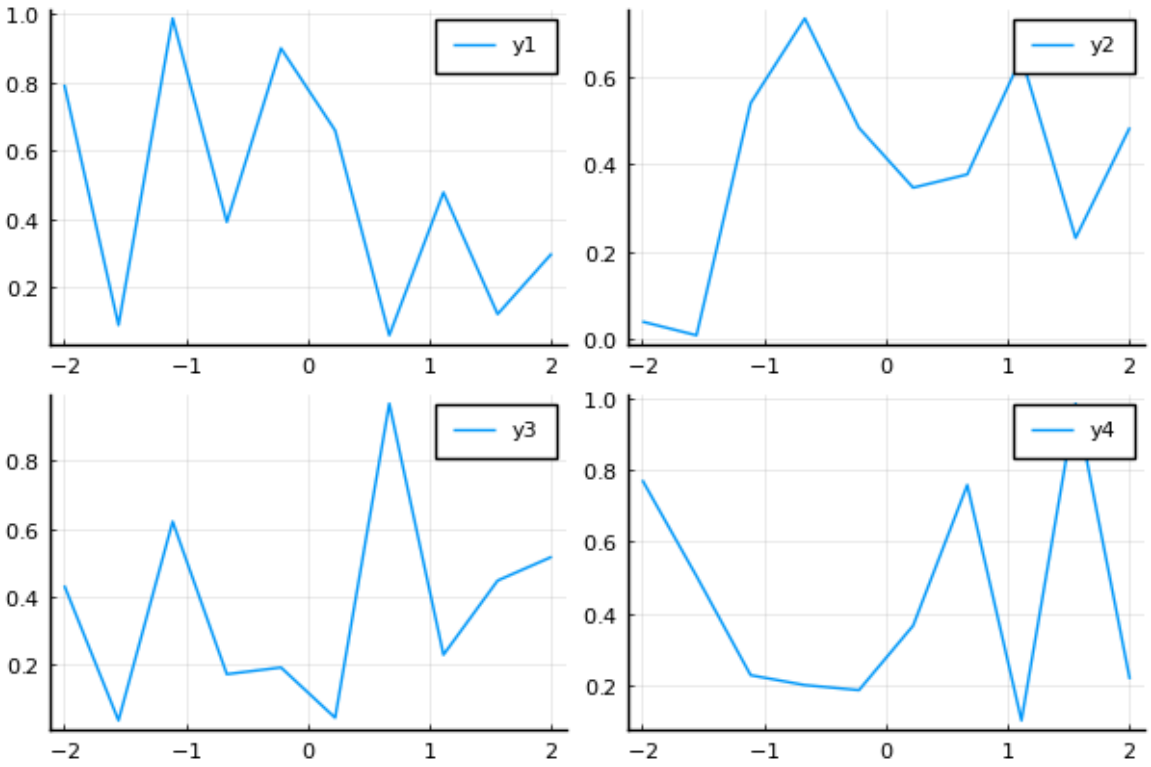
Out[40]:



In [41]:
```
plot(x,y,
layout=4
```

```
)
```

Out[41]:



In [42]:

```
plot(x,y,
    size=(600,300),
    layout = grid(4,1,heights=[0.2,0.3,0.4,0.15])
)
```

```
The heights provided ([0.2, 0.3, 0.4, 0.15]) must sum to 1.

Stacktrace:
 [1] error(s::String)
   @ Base ./error.jl:35
 [2] Plots.GridLayout(::Int64, ::Vararg{Int64}; parent::Plots.RootLayout, wi
dths::Nothing, heights::Vector{Float64}, kw::@Kwargs{})
   @ Plots ~/.julia/packages/Plots/Ec1L1/src/layouts.jl:221
 [3] grid(::Int64, ::Vararg{Int64}; kw::@Kwargs{heights::Vector{Float64}})
   @ Plots ~/.julia/packages/Plots/Ec1L1/src/layouts.jl:209
 [4] top-level scope
   @ In[42]:1
```

In [43]:

```
# график в виде линий:
p1 = plot(x,y)
# график в виде точек:
p2 = scatter(x,y)
# график в виде линий с оформлением:
p3 = plot(x,y[:,1:2],xlabel="Labelled plot of two columns",lw=2,title="Wide
# 4 гистограммы:
p4 = histogram(x,y)

plot(
    p1,p2,p3,p4,
    layout=(2,2),
```

```
    legend=false,
    size=(800,600),
    background_color = :ivory
)
```

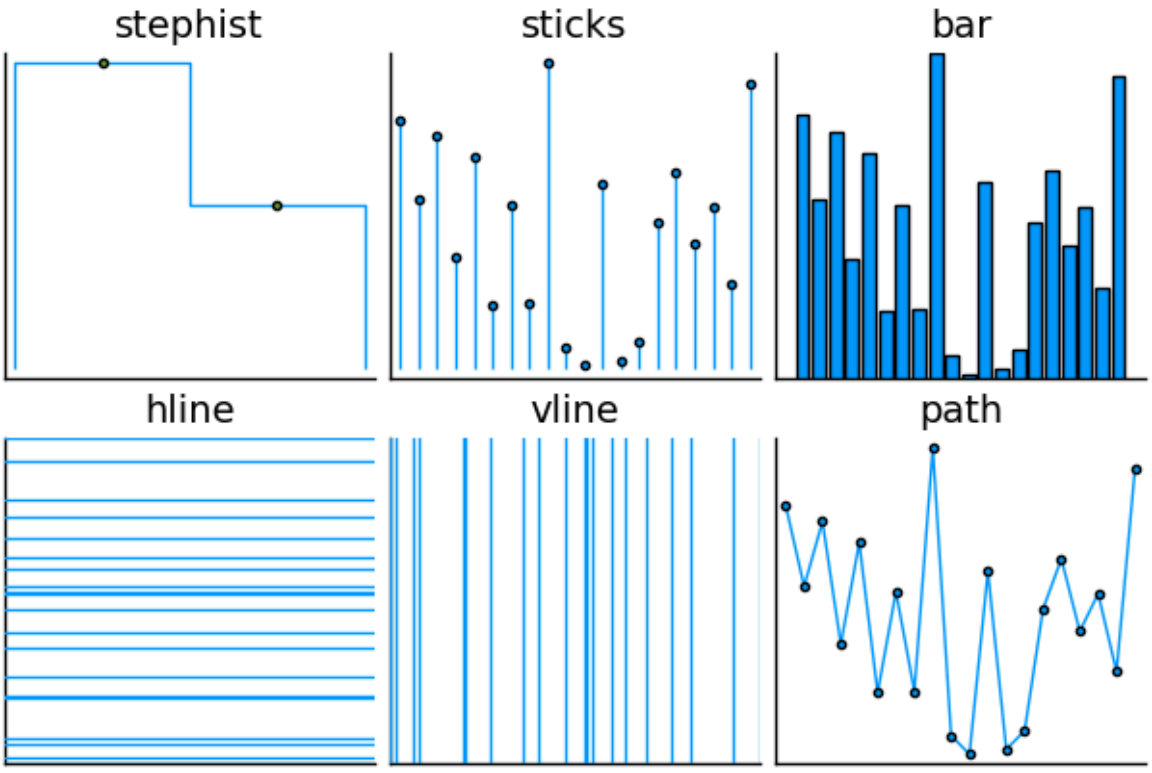
```
UndefVarError: `histogram` not defined in `Main`
Hint: It looks like two or more modules export different bindings with this
name, resulting in ambiguity. Try explicitly importing it from a particular
module, or qualifying the name with the module it should come from.
Hint: a global variable of this name also exists in Plots.
Hint: a global variable of this name also exists in UnicodePlots.

Stacktrace:
 [1] top-level scope
   @ In[43]:8
```

In [44]:

```
seriestypes = [:stephist, :sticks, :bar, :hline, :vline, :path]
titles =["stephist" "sticks" "bar" "hline" "vline" "path"]
plot(rand(20,1), st = seriestypes,
    layout = (2,3),
    ticks=nothing,
    legend=false,
    title=titles,
    m=3
)
```

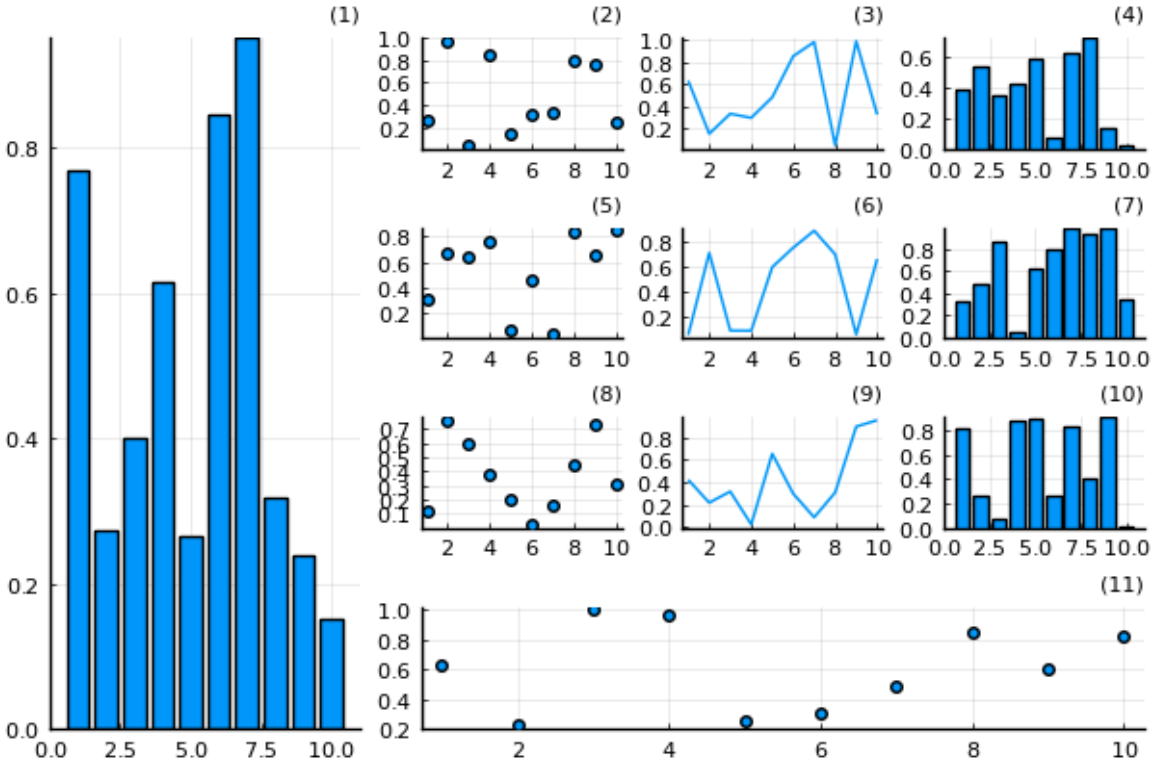
Out[44]:



```
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
```

In [45]:
```
l = @layout [ a{0.3w} [grid(3,3)
b{0.2h} ]]
plot(
    rand(10,11),
    layout = l, legend = false, seriestype = [:bar :scatter :path],
    title = ["($i)" for j = 1:1, i=1:11], titleloc = :right, titlefont = for
)
```

Out[45]:




```
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
```


5.4. Задания для самостоятельного выполнения

1. Постройте все возможные типы графиков (простые, точечные, гистограммы и т.д.) функции y = sin(x), x = 0, 2π. Отобразите все графики в одном графическом окне.

In [46]:
```
f4(x) = sin.(x)
# сгенерируем масссив значений x в диапазоне от 0 до П
x = collect(range(0, 2*pi, length=200))
# зададим функцию
y = f4(x)

fig1 = plot(x, y,
    title="Simple graphic",
    xlabel="X",
    ylabel="Y",
    color="red")
fig2 = scatter(x, y,
    title="Point graphic",
    xlabel="X",
    ylabel="Y",
    color="red")
fig3 = histogram(f4(x),
    title="Histogram",
    xlabel="X",
    ylabel="Y",
    color="purple")
fig4 = histogram(f4(x),
    bins = 10,
    title="Histogram (bins=10)",
    xlabel="X",
    ylabel="Y",
    color="green")
plot(fig1, fig2, fig3, fig4, layout=(2, 2), legends=false, size=(800, 600))
```

```
UndefVarError: `histogram` not defined in `Main`
Hint: It looks like two or more modules export different bindings with this
name, resulting in ambiguity. Try explicitly importing it from a particular
module, or qualifying the name with the module it should come from.
Hint: a global variable of this name also exists in Plots.
Hint: a global variable of this name also exists in UnicodePlots.

Stacktrace:
 [1] top-level scope
   @ In[46]:17
```

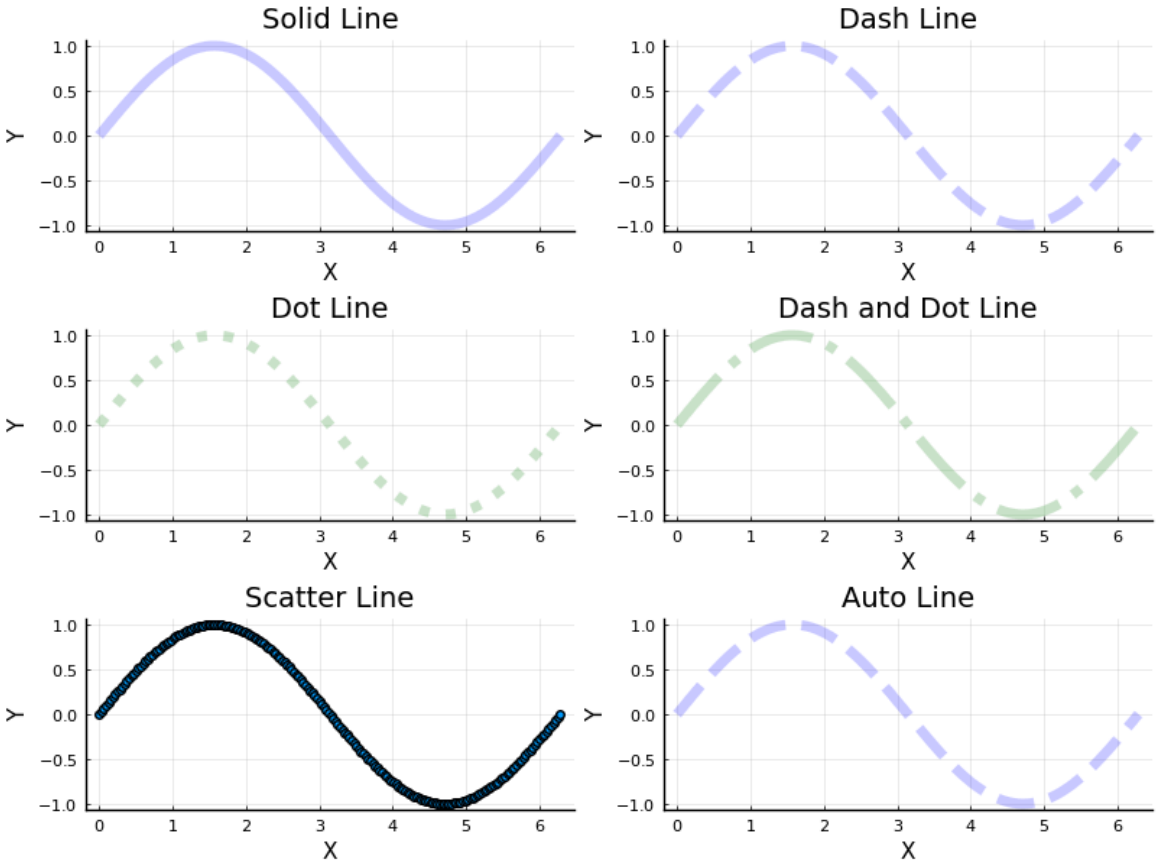
2. Постройте графики функции y = sin(x), x = 0, 2π со всеми возможными (сколько сможете вспомнить) типами оформления линий графика. Отобразите все графики в одном графическом окне.

In [47]:
```
f4(x) = sin.(x)
# сгенерируем масссив значений x в диапазоне от 0 до П с шагом 0.1
x = collect(range(0, 2*pi, length=200))
# зададим функцию
```

```
y = f4(x)

fig1 = plot(x, y,
    title="Solid Line",
    line = (:blue, 0.2, 5, :solid),
    xlabel="X",
    ylabel="Y")
fig2 = plot(x, y,
    title="Dash Line",
    line = (:blue, 0.2, 5, :dash),
    xlabel="X",
    ylabel="Y")
fig3 = plot(x, y,
    line = (:green, 0.2, 5, :dot),
    title="Dot Line",
    xlabel="X",
    ylabel="Y")
fig4 = plot(x, y,
    line = (:green, 0.2, 5, :dashdot),
    title="Dash and Dot Line",
    xlabel="X",
    ylabel="Y")
fig5 = plot(x, y,
    line = (:blue, 0.2, 5, :scatter),
    title="Scatter Line",
    xlabel="X",
    ylabel="Y")
fig6 = plot(x, y,
    line = (:blue, 0.2, 5, :auto),
    title="Auto Line",
    xlabel="X",
    ylabel="Y")
plot(fig1, fig2, fig3, fig4, fig5, fig6, layout=(3, 2), legends=false, size=
```

Out[47]:




```
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
```

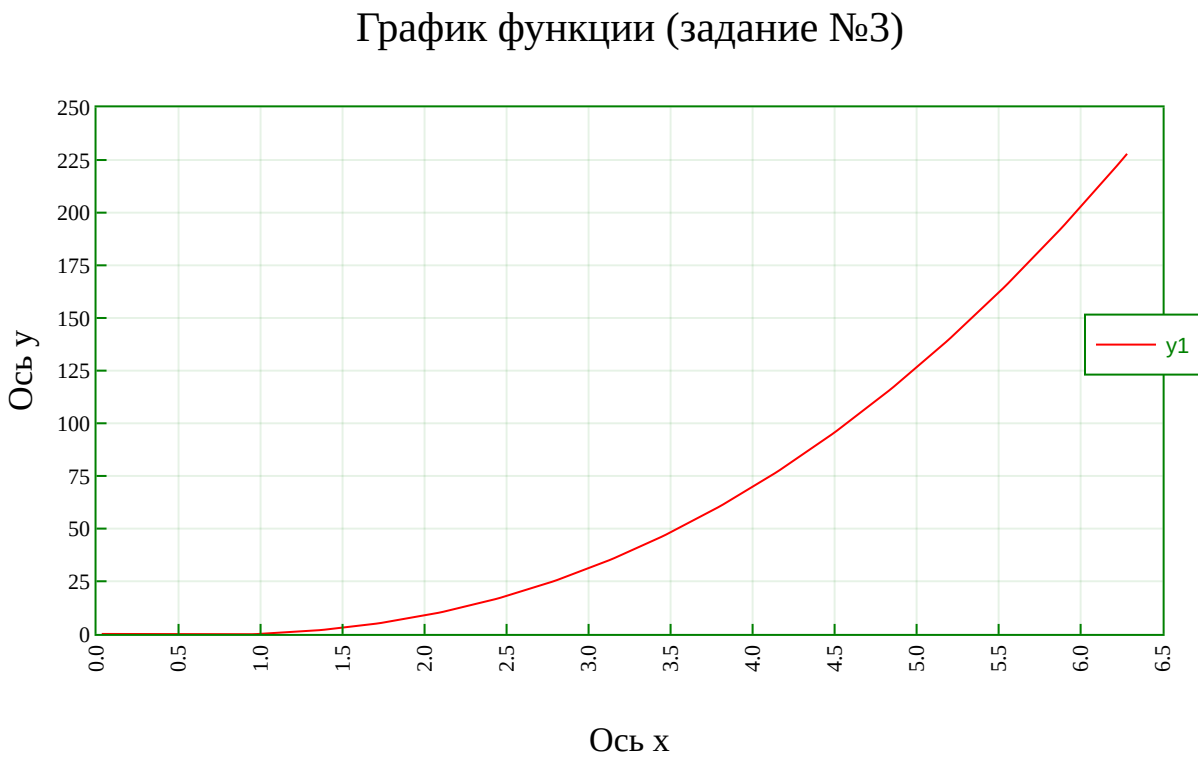
3. Постройте график функции $y(x)$ = πx^2 ln(x), назовите оси соответственно. Пусть цвет рамки будет зелёным, а цвет самого графика — красным. Задайте расстояние между надписями и осями так, чтобы надписи полностью умещались в графическом окне. Задайте шрифт надписей. Задайте частоту отметок на осях координат.

In [48]:

```
using Plots.PlotMeasures
f5(x) = (pi*x.^2).*log.(x)
# сгенерируем масссив значений x в диапазоне от 0 до 2П
x = collect(range(0, 2*pi, length=200))
# зададим функцию
y = f5(x)
plotly()
plot(x,y, color="red", box = :on, foreground_color="green",
    xaxis = ("Ось x", (0, 6.5), 6.5:-0.5:0), yaxis = ("Ось y", (0, 250), 250
    leg=:right,
    title="График функции (задание №3)",
    titlefont = (15, "montserrat", :black),
```

```
    top_margin = 10mm,
    right_margin = 5mm,
    legendfontsize = 8,
    guidefont = (12, "montserrat", :black),
    tickfont = (8, "montserrat",:black),
    xrotation = 90)
```

Out[48]:



4. Задайте вектор x = (−2, −1, 0, 1, 2). В одном графическом окне (в 4-х подокнах)изобразите графически по точкам x значения функции $y(x)$ = x^3 − 3x в виде:
   - точек,
   - линий,
   - линий и точек,
   - кривой.

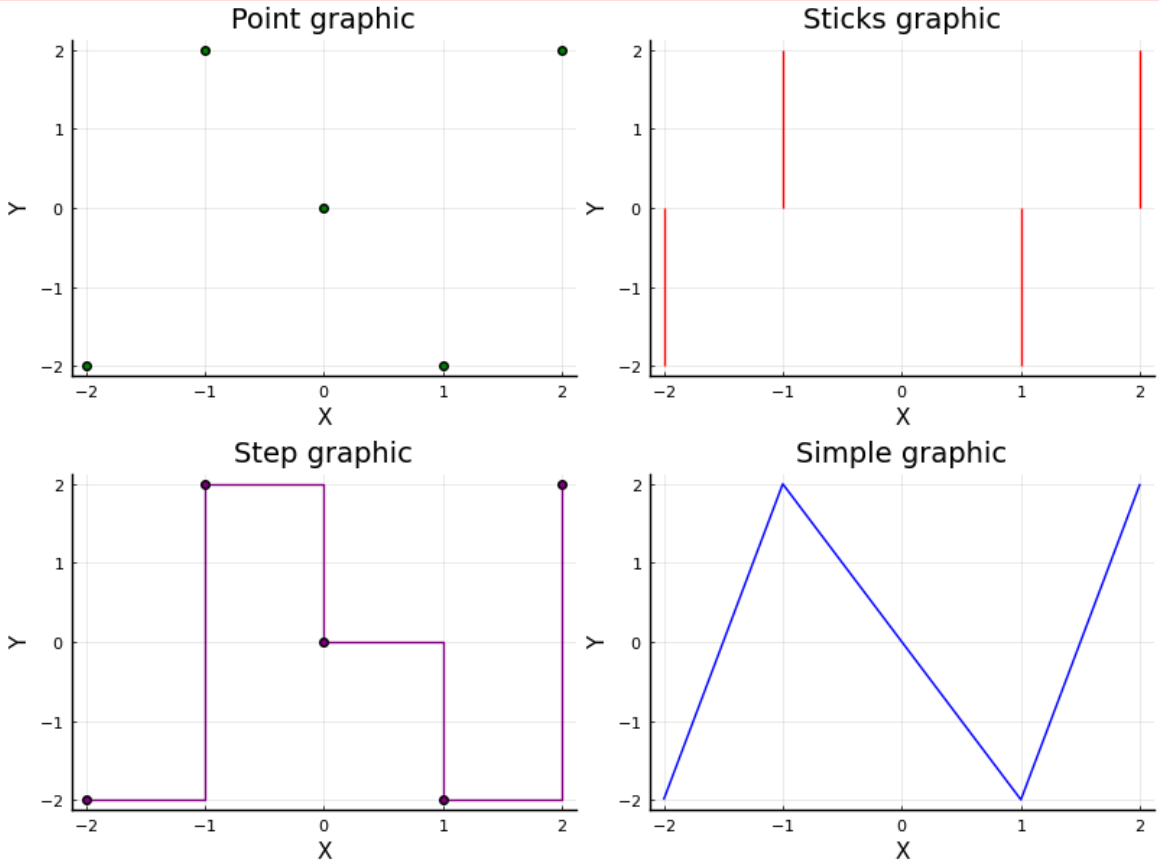
In [49]:

```
# зададим функцию
f(x) = x.^3 - 3*x
x = [-2, -1, 0, 1, 2]
y = f(x)
using Plots.PlotMeasures
pyplot()
fig1 = scatter(x, y,
    title="Point graphic",
    xlabel="X",
    ylabel="Y",
    color="green")
fig2 = plot(x, y,
    title="Sticks graphic",
    seriestype = :sticks,
```

```
    xlabel="X",
    ylabel="Y",
    color="red")
fig3 = plot(x, y,
    title="Step graphic",
    marker = '.',
    seriestype = :step,
    xlabel="X",
    ylabel="Y",
    color="purple")
fig4 = plot(x, y,
    title="Simple graphic",
    xlabel="X",
    ylabel="Y",
    color="blue")
plot(fig1, fig2, fig3, fig4, layout=(2, 2), legends=false, size=(800, 600))
```

```
┌ Warning: Skipped marker arg ..
└ @ Plots ~/.julia/packages/Plots/Ec1L1/src/args.jl:1149
```

Out[49]:




```
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
```

In [50]:
```
# Сохраню полученное изображение
savefig("figure_solomko.png")
```

```
UndefVarError: `savefig` not defined in `Main`
Hint: It looks like two or more modules export different bindings with this
name, resulting in ambiguity. Try explicitly importing it from a particular
module, or qualifying the name with the module it should come from.
Hint: a global variable of this name also exists in Plots.
Hint: a global variable of this name also exists in PyPlot.
Hint: a global variable of this name also exists in UnicodePlots.

Stacktrace:
 [1] top-level scope
   @ In[50]:2
```

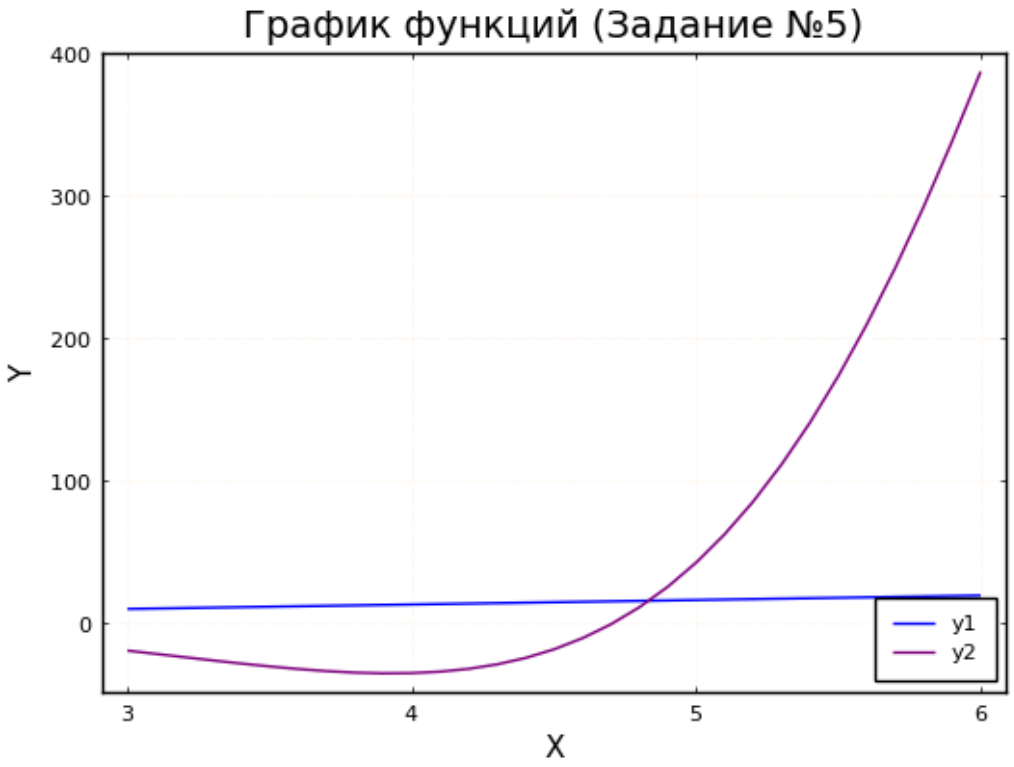
5. Задайте вектор x = (3, 3.1, 3.2, … , 6). Постройте графики функций $y1(x) = \pi x$ и $y2(x) = \exp(x)\cos(x)$ в указанном диапазоне значений аргумента x следующим образом:
   - постройте оба графика разного цвета на одном рисунке, добавьте легенду и сетку для каждого графика; укажите недостатки у данного построения;
   - постройте аналогичный график с двумя осями ординат.

In [51]:
```
f_1(x) = pi*x
f_2(x) = exp.(x).*cos.(x)
x = [i for i in 3:0.1:6]
y_1 = f_1(x)
y_2 = f_2(x)

pyplot()
plot(x, y_1,
    title="График функций (Задание №5)",
    xlabel="X",
    ylabel="Y",
    leg=:topleft,
    color="blue",
    grid = (:y, :orange, :dot),
    right_margin = 20mm)

plot!(x, y_2,
    color="purple",
    leg=:bottomright,
    grid = :on,
    box = :on)
```

Out[51]:



In [52]:

```
plot(x, y_1,
    title="График функций (Задание №5)",
    xlabel="X",
    ylabel="Y1",
    leg=:topleft,
    color="blue",
    grid = (:y, :orange, :dot),
    right_margin = 20mm)

plot!(twinx(), x, y_2,
    ylabel = "Y2",
    color="purple",
    leg=:bottomright,
    grid = :on,
    box = :on)
```

Out[52]:

6. Постройте график некоторых экспериментальных данных (придумайте сами), учитывая ошибку измерения

In [53]:

```
f_3(x) = x.^2 - 2*x
x = rand(20)
y_3 = f_3(x)3
n = 20

error = 1.23 * y_3 / sqrt(n)

plot(y_3, ylims=(-5, 5), err = error)
```

```
ParseError:
# Error @ ]8;;file:///home/maabedelhay/jupyter/Julia/lab05/In[53]#3:13\In
[53]:3:13]8;;\
x = rand(20)
y_3 = f_3(x)3
#           ╙ ── extra tokens after end of expression

Stacktrace:
 [1] top-level scope
   @ In[53]:3
```

7. Постройте точечный график случайных данных. Подпишите оси, легенду, название графика.

In [54]:
```
x = rand(20)
y = rand(20)

scatter(x, y,
    title = "Точечный график случайных чисел",
    label = "Точки (x; y)",
    leg = :topright,
    xlabel="X",
    ylabel="Y")
```

Out[54]:

```
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
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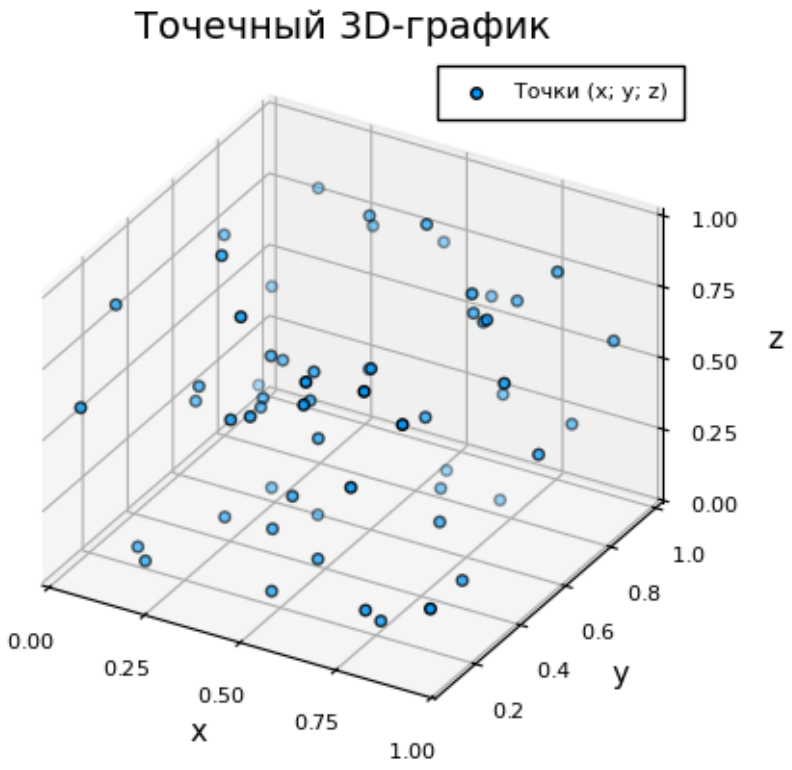
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
```

8. Постройте 3-мерный точечный график случайных данных. Подпишите оси, легенду, название графика.

In [55]:
```
x = rand(60)
y = rand(60)
z = rand(60)

scatter(x, y, z,
    xlabel = "x",
    ylabel = "y",
    zlabel = "z",
    label = "Точки (x; y; z)",
    title = "Точечный 3D-график")
```

Out[55]:



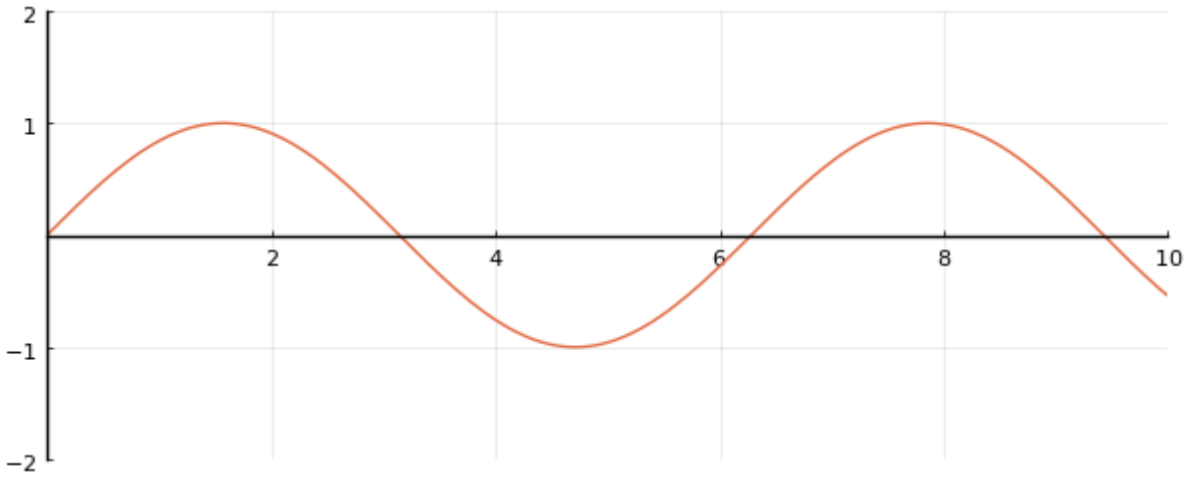

```
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
```

9. Создайте анимацию с построением синусоиды. То есть вы строите последовательность графиков синусоиды, постепенно увеличивая значение аргумента. После соедините их в анимацию.

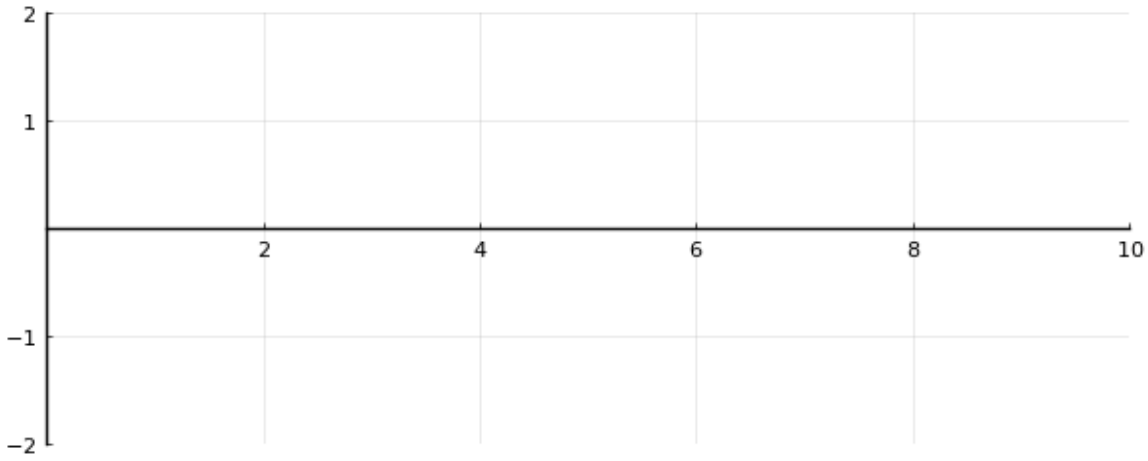
In [56]:
```
n = 300
x = collect(0*pi : 2*pi/100 : 10*pi+pi/100)

anim = @animate for i in 1:n
    fig = plot(1,
                xlim=(0, 10),
                ylim=(-2, 2),
                c=:purple,
                aspect_ratio=1,
                legend=false,
                framestyle=:origin)
    step = x[1 : i]
    y = sin.(step)
    plot!(step, y)
end
#Сохранила анимацию в gif-файл
gif(anim, "sinusoida.gif")
```

```
[ Info: Saved animation to /home/maabedelhay/jupyter/Julia/lab05/sinusoida.g
if
```



Out[56]:



10. Постройте анимированную гипоциклоиду для 2 целых значений модуля k и 2 рациональных значений модуля k.

In [57]:

```
function hypocycloid(x, r0, n)
    # радиус малой окружности:
    r0 = r0
    # коэффициент для построения большой окружности:
    k = x
    # число отсчётов:
    count = n
    # массив значений угла θ:
    θ = collect(0: 2*π/100 : 10*π+2*π/count)

    # массивы значений координат:
    x_1 = r0 * k * cos.(θ)
    y_1 = r0 * k * sin.(θ)
    #В конце сделаем анимацию получившегося изображения
    anim = @animate for i in 1:count
        # задаём оси координат:
        plt=plot(5,
            xlim=(-k-1, k+1),
            ylim=(-k-1, k+1),
            color=:red,
            aspect_ratio=1,
            legend=false,
            framestyle=:origin)
        # большая окружность:
        plot!(plt, x_1, y_1, c=:blue, legend=false)
        t = θ[1 : i]
```

```
        # гипоциклоида:
        x = r0 * (k-1) * cos.(t) + r0 * cos.((k-1) * t)
        y = r0 * (k-1) * sin.(t) - r0 * sin.((k-1) * t)
        plot!(x,y, color=:purple)

        # малая окружность:
        x_r0 = r0*(k-1)*cos(t[end]) .+ r0*cos.(θ)
        y_r0 = r0*(k-1)*sin(t[end]) .+ r0*sin.(θ)
        plot!(x_r0, y_r0, color=:red)

        # радиус малой окружности:
        xl_r0 = transpose([r0*(k-1)*cos(t[end]) x[end]])
        yl_r0 = transpose([r0*(k-1)*sin(t[end]) y[end]])
        plot!(xl_r0, yl_r0,
            markershape=:circle,
            markersize=4,
            color=:black)
        scatter!([x[end]],
            [y[end]],
            color=:red,
            markerstrokecolor=:red)
    end
    gif(anim,"hypocycloid.gif")
end
```

Out[57]: hypocycloid (generic function with 1 method)

In [58]:
```
# первый вариант
hypocycloid(4, 1, 100)
```

```
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
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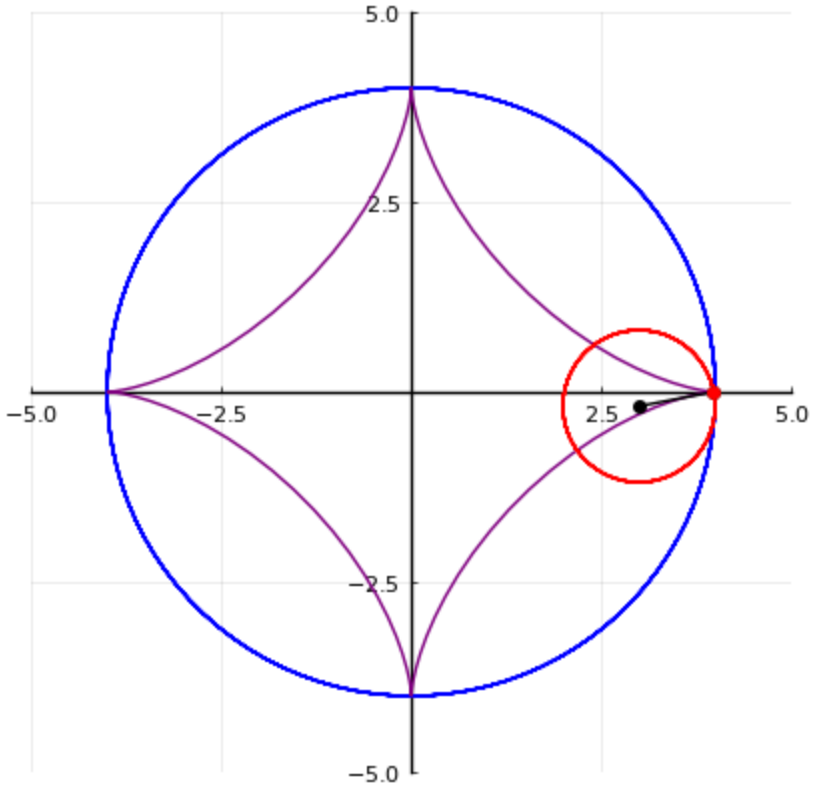
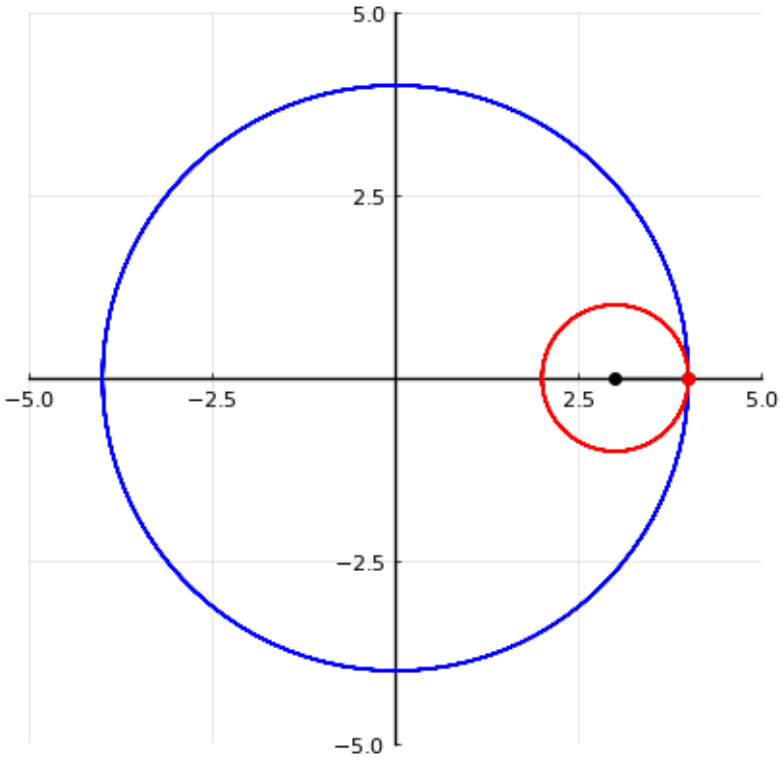
[ Info: Saved animation to /home/maabedelhay/jupyter/Julia/lab05/hypocycloi
d.gif
```



Out[58]:



In [59]:
```
# второй вариант
hypocycloid(5, 1, 100)
```

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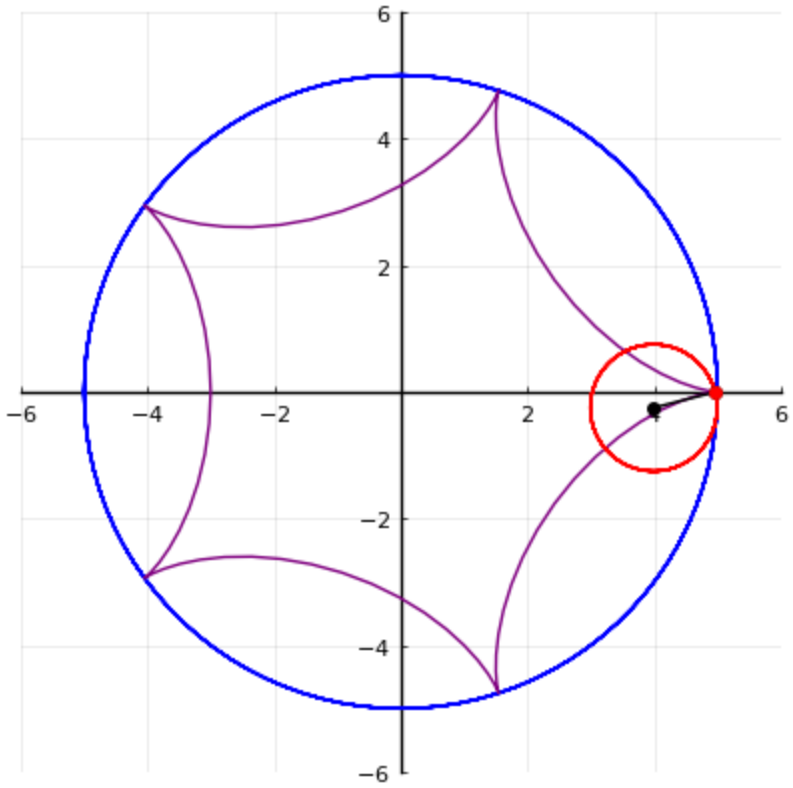
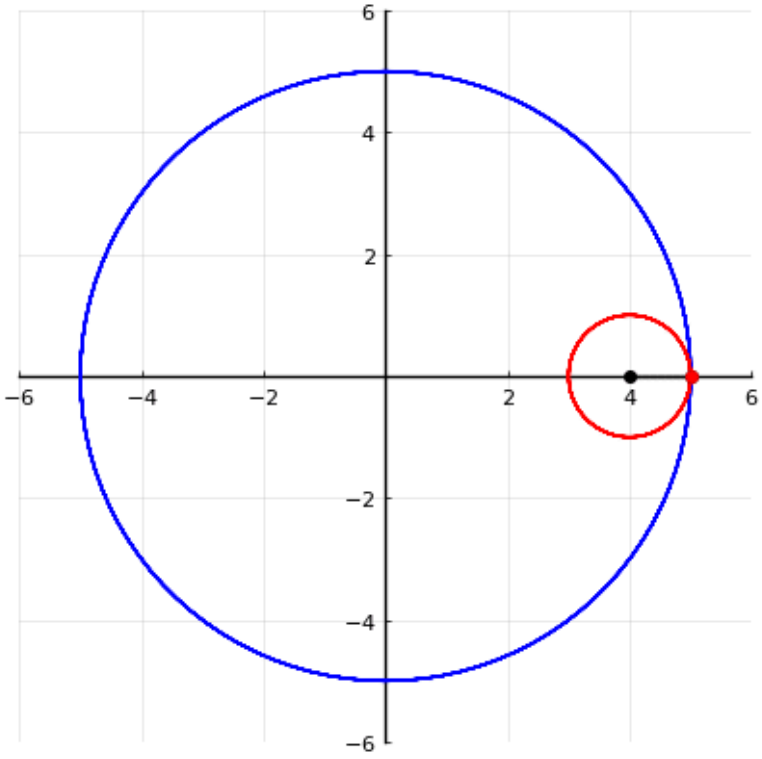
[ Info: Saved animation to /home/maabedelhay/jupyter/Julia/lab05/hypocycloi
d.gif
```



Out[59]:



In [60]:
```
# третий вариант
hypocycloid(1.5, 1, 200)
```

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sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
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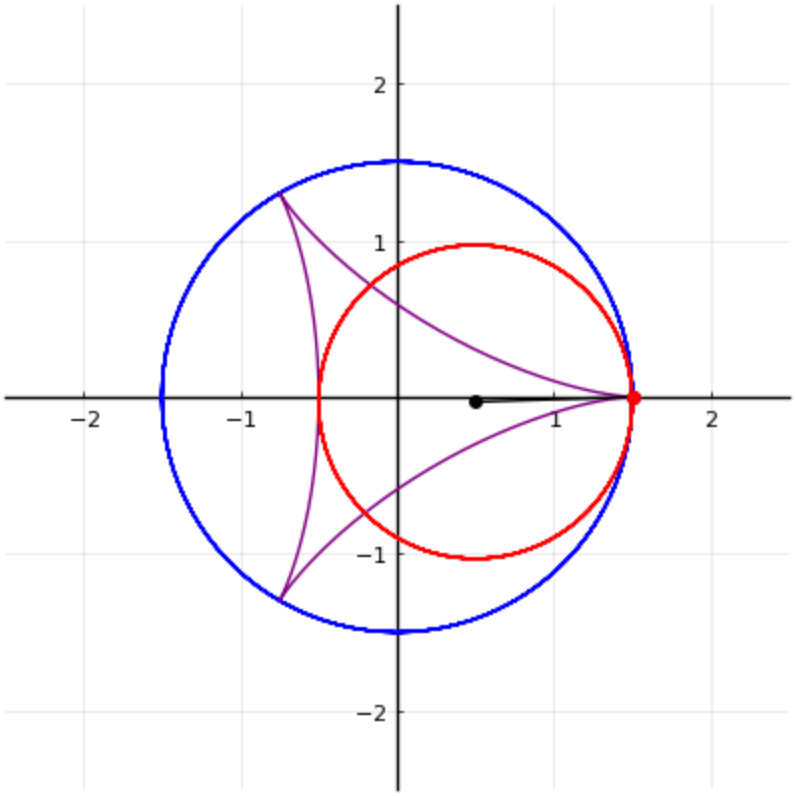
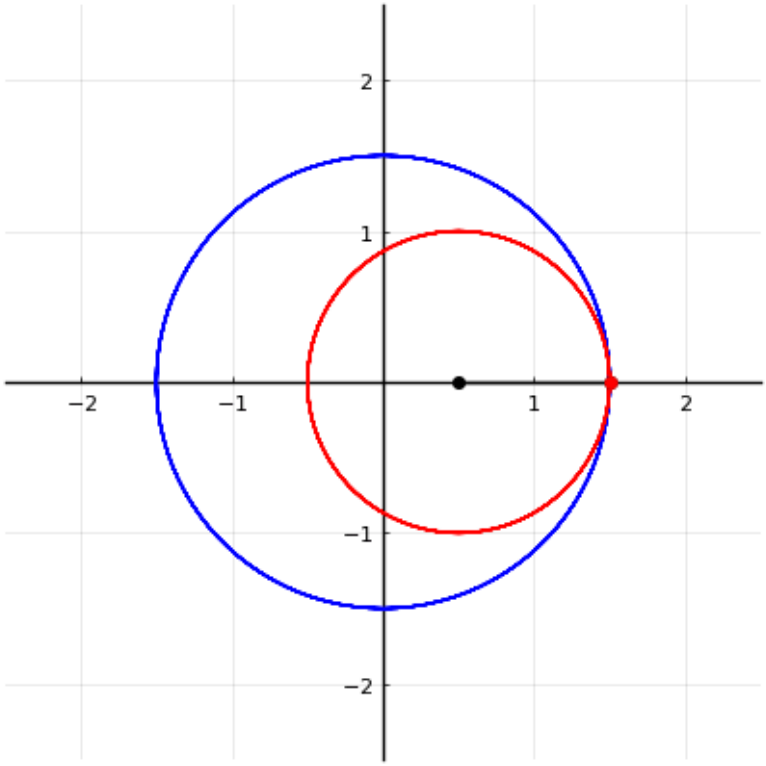
[ Info: Saved animation to /home/maabedelhay/jupyter/Julia/lab05/hypocycloi
d.gif
```



Out[60]:



In [61]:
```
# четвертый вариант
hypocycloid(5.5, 1, 200)
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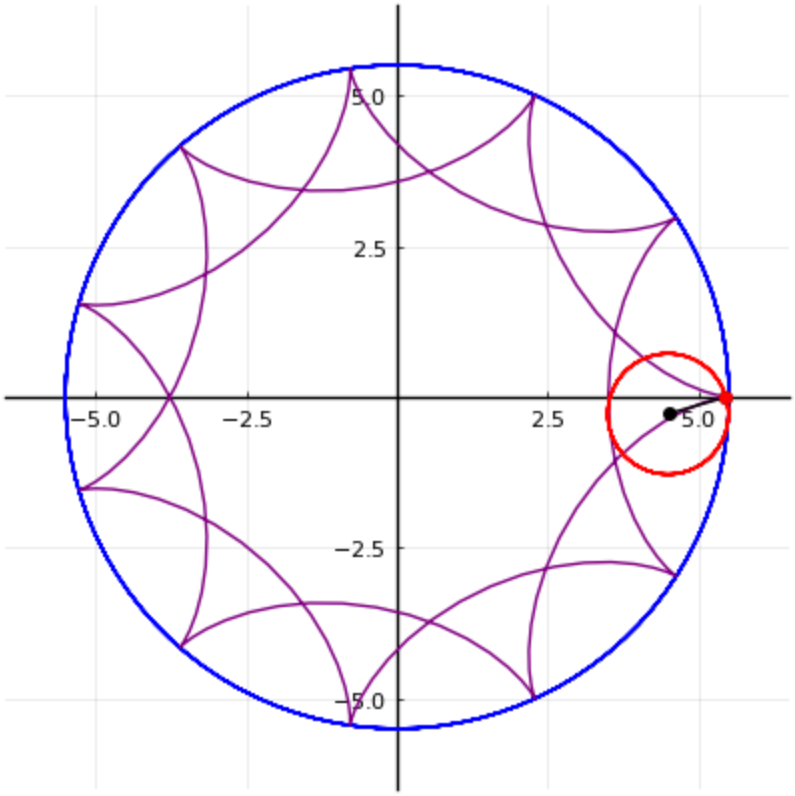
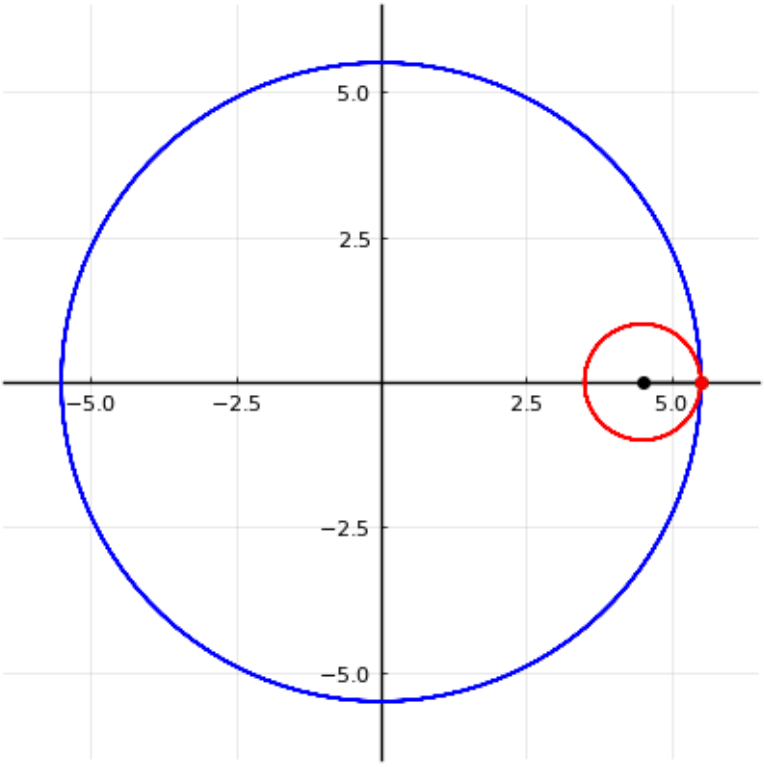
sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
[ Info: Saved animation to /home/maabedelhay/jupyter/Julia/lab05/hypocycloi
d.gif
```



Out[61]:



11. Постройте анимированную эпициклоиду для 2 целых значений модуля k и 2 рациональных значений модуля k.

In [62]:

```
function epicycloid(x, r0, n)
    # радиус малой окружности:
    r0 = r0
    # коэффициент для построения большой окружности:
    k = x
    # число отсчётов:
    count = n
    # массив значений угла θ:
    θ = collect(0: 2*π/100 : 10*π+2*π/count)

    # массивы значений координат:
    x_1 = r0 * k * cos.(θ)
    y_1 = r0 * k * sin.(θ)
    #В конце сделаем анимацию получившегося изображения
    anim = @animate for i in 1:count
        # задаём оси координат:
        plt=plot(5,
            xlim=(-2*r0*k*2, 2*r0*k*2),
            ylim=(-2*r0*k*2, 2*r0*k*2),
            color=:red,
            aspect_ratio=1,
            legend=false,
            framestyle=:origin)
        # большая окружность:
        plot!(plt, x_1, y_1, c=:blue, legend=false)
        t = θ[1 : i]
```

```
        # гипоциклоида:
        x = r0 * (k + 1) * cos.(t) - r0 * cos.((k + 1) * t)
        y = r0 * (k + 1) * sin.(t) - r0 * sin.((k + 1) * t)
        plot!(x,y, color=:purple)

        # малая окружность:
        x_r0 = r0*(k + 1)*cos(t[end]) .- r0*cos.(θ)
        y_r0 = r0*(k + 1)*sin(t[end]) .- r0*sin.(θ)
        plot!(x_r0, y_r0, color=:red)

        # радиус малой окружности:
        xl_r0 = transpose([r0*(k + 1)*cos(t[end]) x[end]])
        yl_r0 = transpose([r0*(k + 1)*sin(t[end]) y[end]])
        plot!(xl_r0, yl_r0,
            markershape=:circle,
            markersize=4,
            color=:black)
        scatter!([x[end]],
            [y[end]],
            color=:red,
            markerstrokecolor=:red)
    end
    gif(anim,"epicycloid.gif")
end
```

Out[62]: epicycloid (generic function with 1 method)

In [63]:
```
# первый вариант
epicycloid(2, 1, 100)
```

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sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
min', 'vmax' will be ignored
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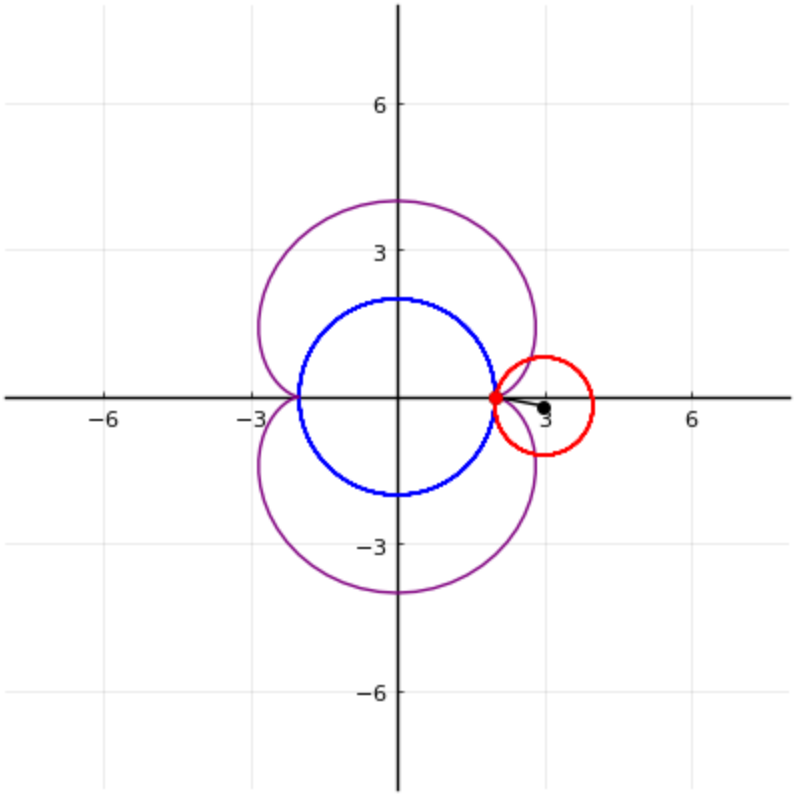
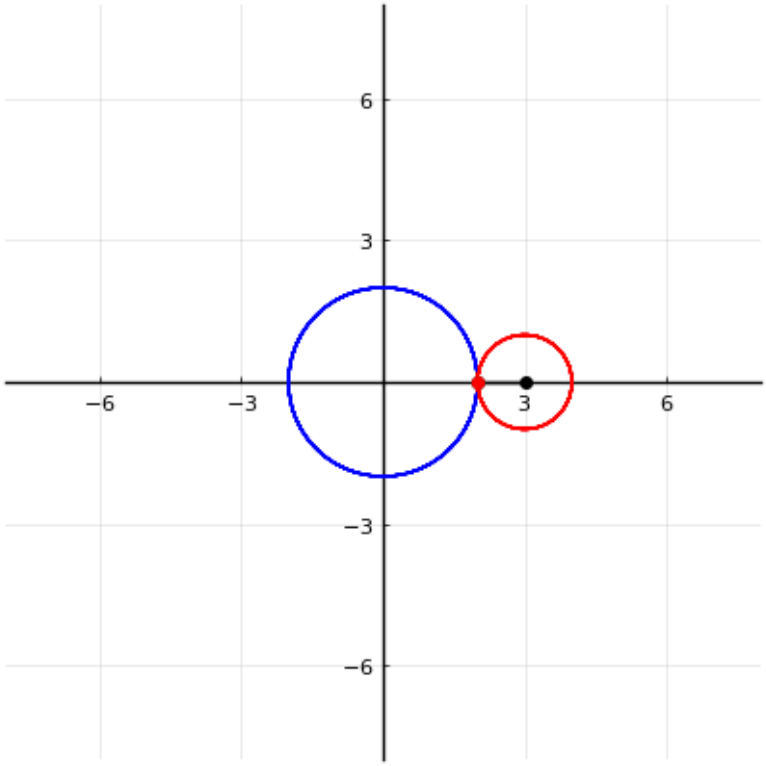
min', 'vmax' will be ignored
[ Info: Saved animation to /home/maabedelhay/jupyter/Julia/lab05/epicycloid.
gif
```



Out[63]:



In [64]:
```
# второй вариант
epicycloid(3, 1, 100)
```

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sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
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min', 'vmax' will be ignored
[ Info: Saved animation to /home/maabedelhay/jupyter/Julia/lab05/epicycloid.
gif
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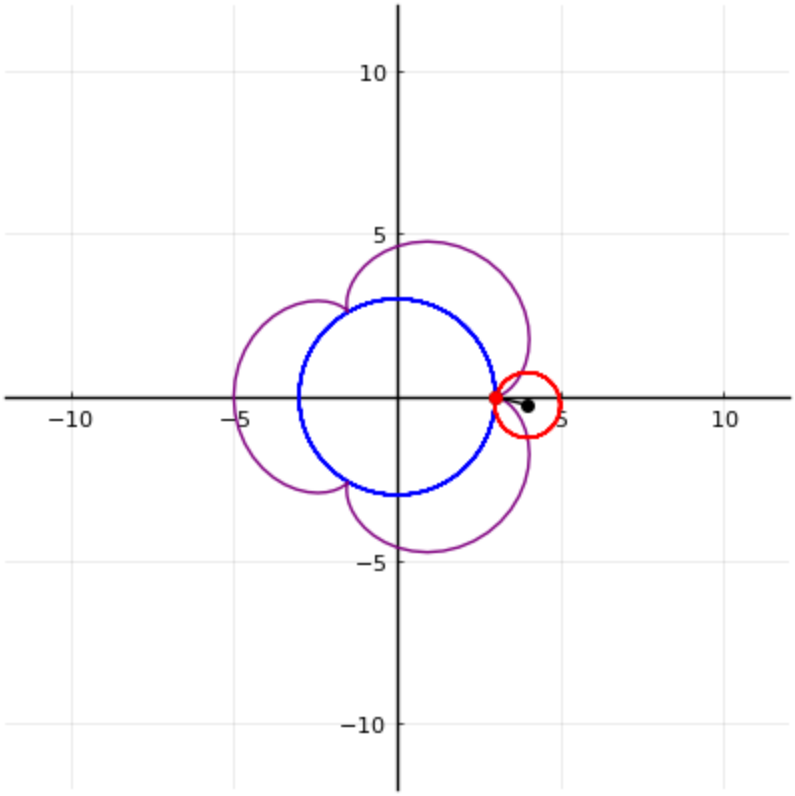
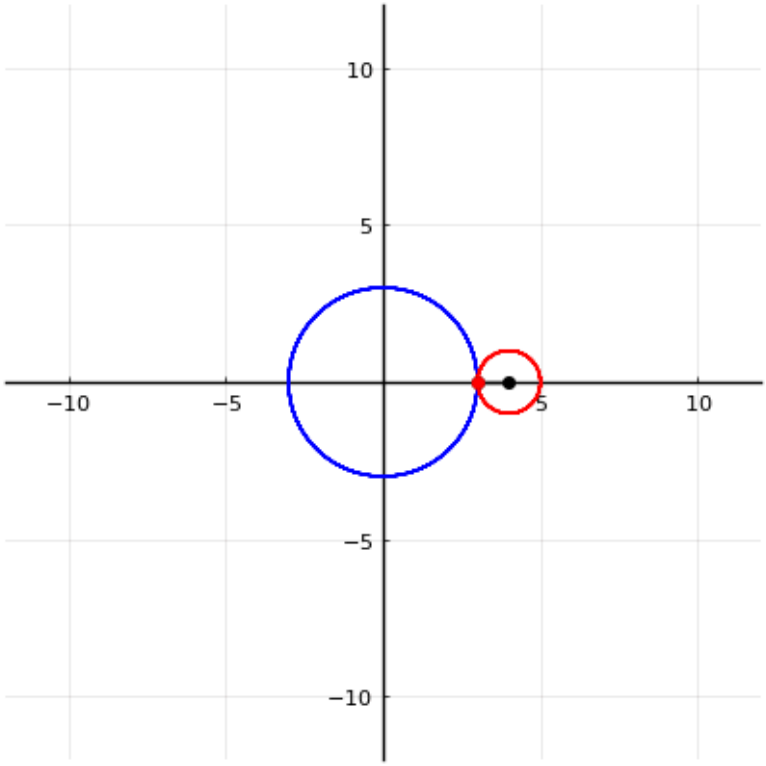


Out[64]:



In [65]:
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# третий вариант
epicycloid(5.5, 1, 500)
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sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
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[ Info: Saved animation to /home/maabedelhay/jupyter/Julia/lab05/epicycloid.
gif
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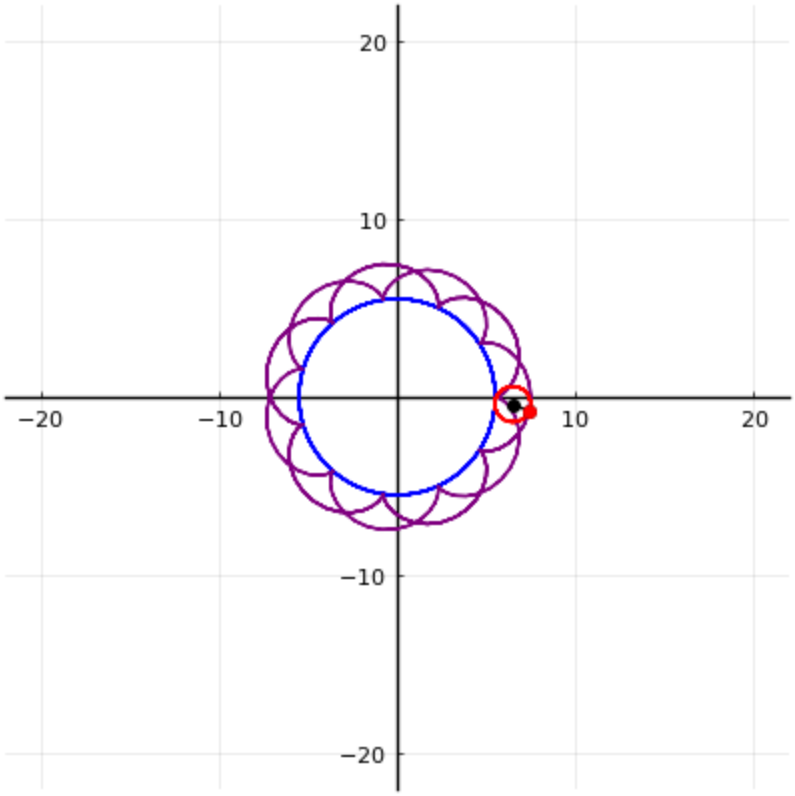
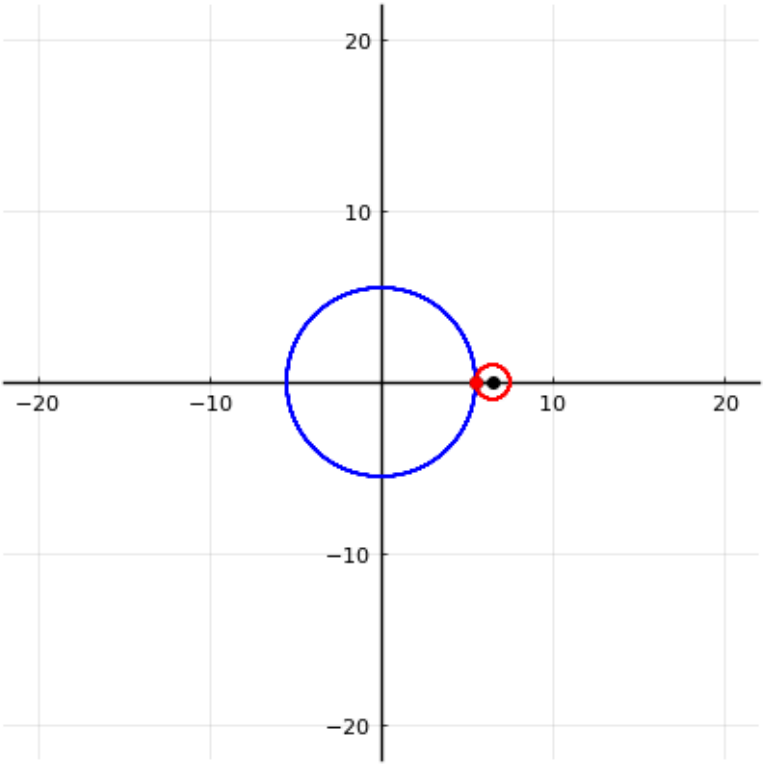


Out[65]:



In [66]:
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# четвертый вариант
epicycloid(3.8, 1, 500)
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sys:1: UserWarning: No data for colormapping provided via 'c'. Parameters 'v
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[ Info: Saved animation to /home/maabedelhay/jupyter/Julia/lab05/epicycloid.
gif
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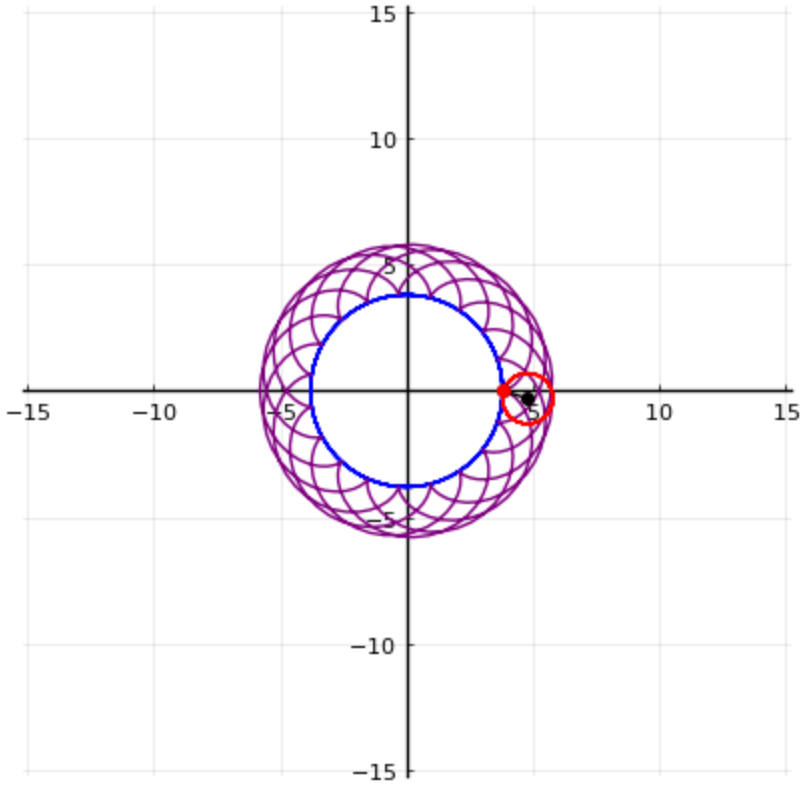
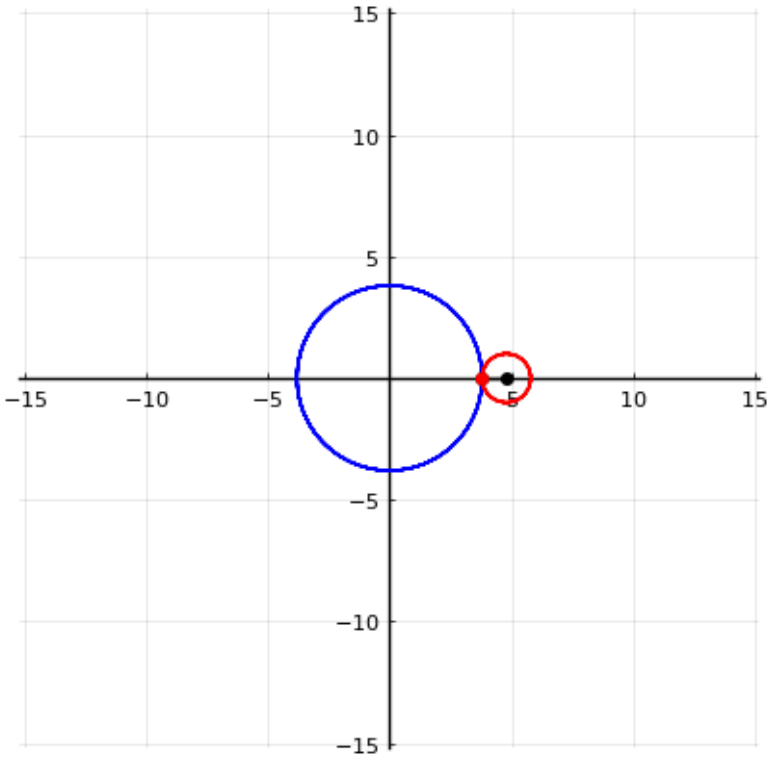
Out[66]: