Lecture 2: Introduction to Julia

Dataset

We will use Traffic Crash Reports data from Cincinnati City.

Data description: Traffic Crash Reports are records in the event of a CPD response to a traffic crash. The source of this data is the City of Cincinnati Police Department. The column names for this data are self explantory.

Filename: "Traffic_Crash_Reports__CPD__Aug2018.csv" *Make sure this file in the same directory as the ipynb file*

Setup: Use Julia 0.6.4 kernel. Install the packages CSV, Gadfly, Cairo and Fontconfig.

In [1]:
```
Pkg.add("CSV",VersionNumber("0.2.5"));
Pkg.add("Gadfly",VersionNumber("0.8.0"));
Pkg.add("Cairo",VersionNumber("0.5.6"));
Pkg.add("Fontconfig",VersionNumber("0.1.1"))
Pkg.add("RDatasets",VersionNumber("0.4.0"))
```

```
INFO: Package CSV is already installed
INFO: Package Gadfly is already installed
WARNING: uuid4(rng) is deprecated, use Compat.UUIDs.uuid4(rng) instead.
Stacktrace:
 [1] depwarn(::String, ::Symbol) at ./deprecated.jl:70
 [2] uuid4(::MersenneTwister) at ./deprecated.jl:57
 [3] msg_header at /usr/local/julia/0.6.4/site/v0.6/IJulia/src/msg.jl:18 [inlined]
 [4] msg_pub(::IJulia.Msg, ::String, ::Dict{String,String}, ::Dict{String,Any}) at /
usr/local/julia/0.6.4/site/v0.6/IJulia/src/msg.jl:30 (repeats 2 times)
 [5] send_stream(::String) at /usr/local/julia/0.6.4/site/v0.6/IJulia/src/stdio.jl:1
72
 [6] send_stdio(::String) at /usr/local/julia/0.6.4/site/v0.6/IJulia/src/stdio.jl:13
0
 [7] (::Base.##302#303{IJulia.#send_stderr,Timer})() at ./event.jl:436
while loading In[1], in expression starting on line 2
INFO: Package Cairo is already installed
WARNING: uuid4(rng) is deprecated, use Compat.UUIDs.uuid4(rng) instead.
Stacktrace:
 [1] depwarn(::String, ::Symbol) at ./deprecated.jl:70
 [2] uuid4(::MersenneTwister) at ./deprecated.jl:57
 [3] msg_header at /usr/local/julia/0.6.4/site/v0.6/IJulia/src/msg.jl:18 [inlined]
 [4] msg_pub(::IJulia.Msg, ::String, ::Dict{String,String}, ::Dict{String,Any}) at /
usr/local/julia/0.6.4/site/v0.6/IJulia/src/msg.jl:30 (repeats 2 times)
 [5] send_stream(::String) at /usr/local/julia/0.6.4/site/v0.6/IJulia/src/stdio.jl:1
72
 [6] send_stdio(::String) at /usr/local/julia/0.6.4/site/v0.6/IJulia/src/stdio.jl:13
0
 [7] (::Base.##302#303{IJulia.#send_stderr,Timer})() at ./event.jl:436
while loading In[1], in expression starting on line 3
INFO: Package Fontconfig is already installed
WARNING: uuid4(rng) is deprecated, use Compat.UUIDs.uuid4(rng) instead.
Stacktrace:
 [1] depwarn(::String, ::Symbol) at ./deprecated.jl:70
 [2] uuid4(::MersenneTwister) at ./deprecated.jl:57
 [3] msg_header at /usr/local/julia/0.6.4/site/v0.6/IJulia/src/msg.jl:18 [inlined]
 [4] msg_pub(::IJulia.Msg, ::String, ::Dict{String,String}, ::Dict{String,Any}) at /
usr/local/julia/0.6.4/site/v0.6/IJulia/src/msg.jl:30 (repeats 2 times)
 [5] send_stream(::String) at /usr/local/julia/0.6.4/site/v0.6/IJulia/src/stdio.jl:1
72
```

```
 [6] send_stdio(::String) at /usr/local/julia/0.6.4/site/v0.6/IJulia/src/stdio.jl:13
0
 [7] (::Base.##302#303{IJulia.#send_stderr,Timer})() at ./event.jl:436
while loading In[1], in expression starting on line 4
INFO: Package RDatasets is already installed
WARNING: uuid4(rng) is deprecated, use Compat.UUIDs.uuid4(rng) instead.
Stacktrace:
 [1] depwarn(::String, ::Symbol) at ./deprecated.jl:70
 [2] uuid4(::MersenneTwister) at ./deprecated.jl:57
 [3] msg_header at /usr/local/julia/0.6.4/site/v0.6/IJulia/src/msg.jl:18 [inlined]
 [4] msg_pub(::IJulia.Msg, ::String, ::Dict{String,String}, ::Dict{String,Any}) at /
usr/local/julia/0.6.4/site/v0.6/IJulia/src/msg.jl:30 (repeats 2 times)
 [5] send_stream(::String) at /usr/local/julia/0.6.4/site/v0.6/IJulia/src/stdio.jl:1
72
 [6] send_stdio(::String) at /usr/local/julia/0.6.4/site/v0.6/IJulia/src/stdio.jl:13
0
 [7] (::Base.##302#303{IJulia.#send_stderr,Timer})() at ./event.jl:436
while loading In[1], in expression starting on line 5
```

Use the packages...

In [2]:
```
using CSV, DataFrames, Gadfly, Cairo, Fontconfig, RDatasets;
```

Questions

Write Julia code to answer the following questions:

Q 1: Load this data (Traffic_Crash_Reports**CPD**Aug2018.csv) into memory.

In [3]:
```
data = CSV.read("Traffic_Crash_Reports__CPD__Aug2018.csv", delim=",", missingstring=
```

Q 2: What is the size of the dataset? How many data points and how many attributes?

In [4]:
```
size(data)
```

Out[4]:
```
(2567, 25)
```

Q 3: Create a new Dataframe 'new_data' by selecting the columns AGE, CRASHSEVERITY, DAYOFWEEK, GENDER, INJURIES, LIGHTCONDITIONSPRIMARY, LOCALREPORTNO, MANNEROFCRASH, ROADSURFACE, WEATHER, and ZIP

*Use the new_data Dataframe for **Q4** and **Q5**.*

In [5]:
```
new_data = data[:, [:AGE, :CRASHSEVERITY, :DAYOFWEEK, :GENDER, :INJURIES, :LIGHTCOND
```

Out[5]:

	AGE	CRASHSEVERITY	DAYOFWEEK	GENDER	INJURIES	LIGHTCONDITIONSPRIMAI
1	18-25	3 - PROPERTY DAMAGE ONLY (PDO)	FRI	M - MALE	1 - NO INJURY / NONE REPORTED	1 - DAYLIGI
2	31-40	2 - INJURY	THU	M - MALE	1 - NO INJURY / NONE REPORTED	1 - DAYLIGI
3	26-30	2 - INJURY	FRI	M - MALE	2 - POSSIBLE	5 - DARK – ROADWAY NO LIGHTI

	AGE	CRASHSEVERITY	DAYOFWEEK	GENDER	INJURIES	LIGHTCONDITIONSPRIMAI
4	41-50	3 - PROPERTY DAMAGE ONLY (PDO)	MON	M - MALE	1 - NO INJURY / NONE REPORTED	1 - DAYLIGI
5	26-30	3 - PROPERTY DAMAGE ONLY (PDO)	FRI	M - MALE	1 - NO INJURY / NONE REPORTED	1 - DAYLIGI
6	UNDER 18	2 - INJURY	WED	F - FEMALE	1 - NO INJURY / NONE REPORTED	1 - DAYLIGI
7	26-30	3 - PROPERTY DAMAGE ONLY (PDO)	SAT	M - MALE	1 - NO INJURY / NONE REPORTED	9 - UNKNOW
8	61-70	3 - PROPERTY DAMAGE ONLY (PDO)	TUE	M - MALE	1 - NO INJURY / NONE REPORTED	1 - DAYLIGI
9	18-25	2 - INJURY	FRI	F - FEMALE	2 - POSSIBLE	1 - DAYLIGI
10	51-60	3 - PROPERTY DAMAGE ONLY (PDO)	TUE	M - MALE	1 - NO INJURY / NONE REPORTED	1 - DAYLIGI
11	UNKNOWN	2 - INJURY	SUN	missing	1 - NO INJURY / NONE REPORTED	4 - DARK - LIGHTI ROADW/
12	51-60	3 - PROPERTY DAMAGE ONLY (PDO)	FRI	F - FEMALE	1 - NO INJURY / NONE REPORTED	4 - DARK - LIGHTI ROADW/
13	51-60	3 - PROPERTY DAMAGE ONLY (PDO)	TUE	M - MALE	1 - NO INJURY / NONE REPORTED	1 - DAYLIGI
14	41-50	2 - INJURY	THU	F - FEMALE	3 - NON-INCAPACITATING	3 - DU
15	18-25	3 - PROPERTY DAMAGE ONLY (PDO)	WED	F - FEMALE	1 - NO INJURY / NONE REPORTED	1 - DAYLIGI
16	UNKNOWN	3 - PROPERTY DAMAGE ONLY (PDO)	TUE	missing	1 - NO INJURY / NONE REPORTED	1 - DAYLIGI
17	18-25	3 - PROPERTY DAMAGE ONLY (PDO)	SAT	M - MALE	1 - NO INJURY / NONE REPORTED	4 - DARK - LIGHTI ROADW/
18	UNKNOWN	3 - PROPERTY DAMAGE ONLY (PDO)	SAT	missing	1 - NO INJURY / NONE REPORTED	4 - DARK - LIGHTI ROADW/

	AGE	CRASHSEVERITY	DAYOFWEEK	GENDER	INJURIES	LIGHTCONDITIONSPRIMAI
19	18-25	3 - PROPERTY DAMAGE ONLY (PDO)	SAT	M - MALE	1 - NO INJURY / NONE REPORTED	4 - DARK - LIGHTI ROADW/
20	26-30	3 - PROPERTY DAMAGE ONLY (PDO)	TUE	M - MALE	1 - NO INJURY / NONE REPORTED	1 - DAYLIGI
21	31-40	3 - PROPERTY DAMAGE ONLY (PDO)	FRI	F - FEMALE	1 - NO INJURY / NONE REPORTED	1 - DAYLIGI
22	18-25	3 - PROPERTY DAMAGE ONLY (PDO)	THU	M - MALE	1 - NO INJURY / NONE REPORTED	1 - DAYLIGI
23	41-50	3 - PROPERTY DAMAGE ONLY (PDO)	SUN	M - MALE	1 - NO INJURY / NONE REPORTED	1 - DAYLIGI
24	51-60	3 - PROPERTY DAMAGE ONLY (PDO)	FRI	M - MALE	1 - NO INJURY / NONE REPORTED	4 - DARK - LIGHTI ROADW/
25	26-30	2 - INJURY	TUE	M - MALE	1 - NO INJURY / NONE REPORTED	1 - DAYLIGI
26	61-70	3 - PROPERTY DAMAGE ONLY (PDO)	TUE	M - MALE	1 - NO INJURY / NONE REPORTED	1 - DAYLIGI
27	31-40	3 - PROPERTY DAMAGE ONLY (PDO)	MON	F - FEMALE	1 - NO INJURY / NONE REPORTED	1 - DAYLIGI
28	31-40	3 - PROPERTY DAMAGE ONLY (PDO)	SAT	M - MALE	1 - NO INJURY / NONE REPORTED	1 - DAYLIGI
29	31-40	3 - PROPERTY DAMAGE ONLY (PDO)	MON	M - MALE	1 - NO INJURY / NONE REPORTED	1 - DAYLIGI
30	UNKNOWN	2 - INJURY	FRI	missing	1 - NO INJURY / NONE REPORTED	4 - DARK - LIGHTI ROADW/
⋮	⋮	⋮	⋮	⋮	⋮	

Q 4: Using describe() function, list the different element types in the new data frame. Also list the columns in which there are missing values.

In [6]:
```
describe(new_data[:, :])
```

Out[6]:

	variable	mean	min	median	max	nunique	nmissing	
1	AGE					9	0	CategoricalArrays.
2	CRASHSEVERITY					3	0	CategoricalArrays.
3	DAYOFWEEK					7	0	CategoricalArrays.

	variable	mean	min	median	max	nunique	nmissing	
4	GENDER					2	299	CategoricalArrays.
5	INJURIES					5	10	CategoricalArrays.
6	LIGHTCONDITIONSPRIMARY					8	0	CategoricalArrays.
7	LOCALREPORTNO					1319	0	CategoricalArrays.
8	MANNEROFCRASH					9	0	CategoricalArrays.
9	ROADSURFACE					5	0	CategoricalArrays.
10	WEATHER					5	0	CategoricalArrays.
11	ZIP	45217.2	45202	45216.0	45251		18	

Q 5: Create a new dataframe 'newdata_nomissing' by removing the rows in the missing values from the new_data Dataframe. How many rows have been removed in this process?

In [7]:
```
size(new_data)
```

Out[7]:
```
(2567, 11)
```

In [25]:
```
new_data_nomissing = dropmissing(new_data);
size(new_data_nomissing)
```

Out[25]:
```
(2250, 11)
```

317 rows were removed by this process. As per the nmissing data it should be 327, but dropmissing is removing 317.

*For the following questions until **Q15** use new_data_nomissing dataframe.*

Q 6: Generate a list of the different types of crashes in this data.

In [9]:
```
unique(new_data_nomissing[:MANNEROFCRASH])
```

Out[9]:
```
9-element Array{Union{Missings.Missing, String},1}:
 "2 - REAR-END"
 "6 - ANGLE"
 "8 - SIDESWIPE, OPPOSITE DIRECTION"
 "5 - BACKING"
 "1 - NOT COLLISION BETWEEN TWO MOTOR VEHICLES IN TRANSPORT"
 "7 - SIDESWIPE, SAME DIRECTION"
 "3 - HEAD-ON"
 "9 - UNKNOWN"
 "4 - REAR-TO-REAR"
```

Q 7: Generate a list of the different types of WEATHER conditions in this data.

In [10]:
```
unique(new_data_nomissing[:WEATHER])
```

Out[10]:
```
5-element Array{Union{Missings.Missing, String},1}:
 "1 - CLEAR"
 "2 - CLOUDY"
 "4 - RAIN"
 "9 - OTHER/UNKNOWN"
 "3 - FOG, SMOG, SMOKE"
```

Q 8: Determine the number of crashes happened in each of these weather conditions using by() function.

In [11]:
```
ans = by(new_data_nomissing, :WEATHER, nrow)
```

```
WARNING: imported binding for ans overwritten in module Main
```

Out[11]:

	WEATHER	x1
1	1 - CLEAR	1519
2	2 - CLOUDY	402
3	4 - RAIN	321
4	9 - OTHER/UNKNOWN	7
5	3 - FOG, SMOG, SMOKE	1

Q 9: Generate a list of the different light conditions in this data.

In [12]:
```
unique(new_data_nomissing[:LIGHTCONDITIONSPRIMARY])
```

Out[12]:
```
7-element Array{Union{Missings.Missing, String},1}:
 "1 - DAYLIGHT"
 "5 - DARK – ROADWAY NOT LIGHTED"
 "9 - UNKNOWN"
 "4 - DARK - LIGHTED ROADWAY"
 "6 - DARK – UNKNOWN ROADWAY LIGHTING"
 "2 - DAWN"
 "3 - DUSK"
```

Q 10: Determine the number of crashes happened in each combination of weather and light conditions using by() function. State which combination of weather and ligt conditions result in most number of crashes.

In [13]:
```
ans1 = by(new_data_nomissing, [:WEATHER, :LIGHTCONDITIONSPRIMARY], nrow)
```

Out[13]:

	WEATHER	LIGHTCONDITIONSPRIMARY	x1
1	1 - CLEAR	1 - DAYLIGHT	1200
2	1 - CLEAR	5 - DARK – ROADWAY NOT LIGHTED	9
3	2 - CLOUDY	1 - DAYLIGHT	347
4	4 - RAIN	1 - DAYLIGHT	245
5	1 - CLEAR	9 - UNKNOWN	1
6	1 - CLEAR	4 - DARK - LIGHTED ROADWAY	259
7	4 - RAIN	4 - DARK - LIGHTED ROADWAY	62
8	2 - CLOUDY	4 - DARK - LIGHTED ROADWAY	37
9	1 - CLEAR	6 - DARK – UNKNOWN ROADWAY LIGHTING	4
10	4 - RAIN	2 - DAWN	8
11	1 - CLEAR	2 - DAWN	9
12	1 - CLEAR	3 - DUSK	37
13	2 - CLOUDY	3 - DUSK	9

	WEATHER	LIGHTCONDITIONSPRIMARY	x1
14	4 - RAIN	5 - DARK – ROADWAY NOT LIGHTED	3
15	2 - CLOUDY	9 - UNKNOWN	1
16	9 - OTHER/UNKNOWN	4 - DARK - LIGHTED ROADWAY	4
17	2 - CLOUDY	2 - DAWN	6
18	2 - CLOUDY	5 - DARK – ROADWAY NOT LIGHTED	2
19	9 - OTHER/UNKNOWN	9 - UNKNOWN	2
20	4 - RAIN	3 - DUSK	3
21	3 - FOG, SMOG, SMOKE	4 - DARK - LIGHTED ROADWAY	1
22	9 - OTHER/UNKNOWN	1 - DAYLIGHT	1

Clear and Daylight conditions count for most number of crashes.

Q 11: How many ZIP codes are covered in this data.

In [14]:
```
a = unique(new_data_nomissing[:ZIP])
size(unique(new_data_nomissing[:ZIP]))
```

Out[14]: (33,)

For the following questions that involve generating plots, you may use the white_panel theme.

In [15]:
```
white_panel = Theme(
    panel_fill=colorant"white",
    default_color=colorant"blue",
    major_label_font_size=12pt,
    minor_label_font_size=12pt,
    major_label_color=colorant"black",
    minor_label_color=colorant"black",
);
```

Q 12: Plot a bar graph showing the number of accidents in each of the ZIP codes

In [16]:
```
ans = by(new_data_nomissing, :ZIP, nrow)
```

Out[16]:

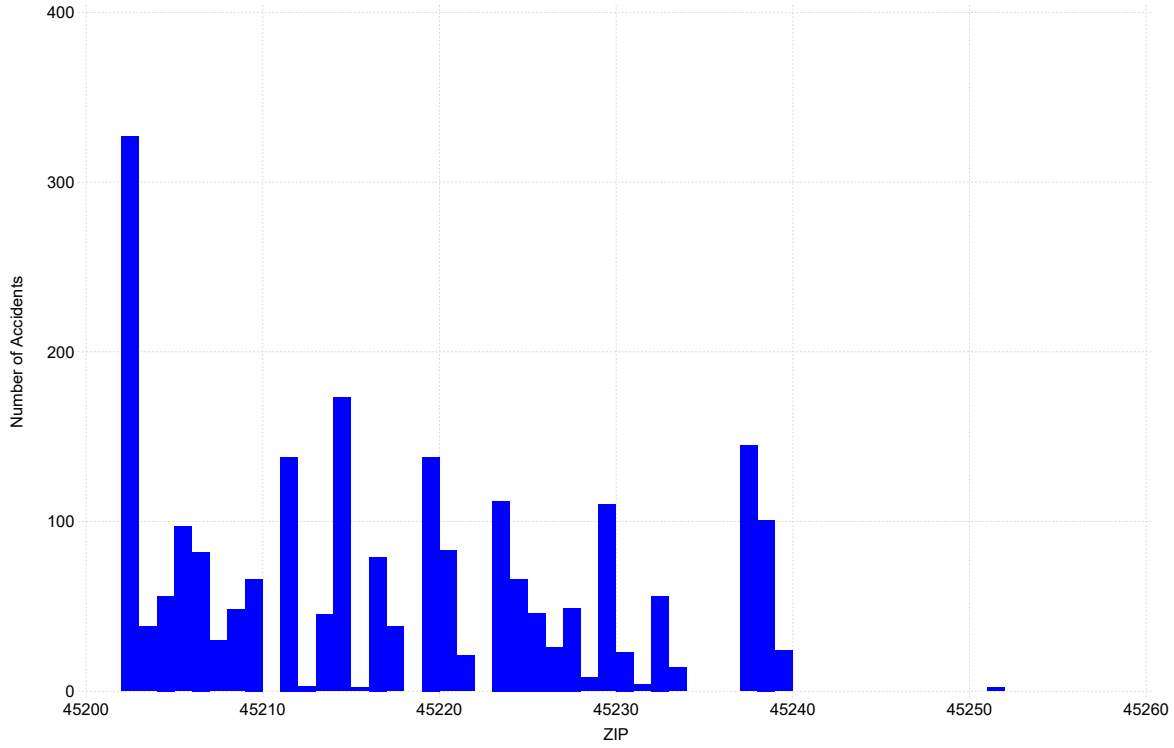
	ZIP	x1
1	45237	145
2	45211	138
3	45205	97
4	45208	48
5	45214	173
6	45213	45
7	45223	112
8	45219	138
9	45229	110
10	45220	83

	ZIP	x1
11	45204	56
12	45202	327
13	45238	101
14	45232	56
15	45207	30
16	45216	79
17	45225	46
18	45227	49
19	45239	24
20	45226	26
21	45206	82
22	45209	66
23	45224	66
24	45217	38
25	45203	38
26	45221	21
27	45251	2
28	45228	8
29	45233	14
30	45230	23
⋮	⋮	⋮

In [17]:

```
set_default_plot_size(12inch,8inch)
myplot1 = Gadfly.plot(new_data_nomissing, x = "ZIP", Geom.histogram, Guide.ylabel("N
draw(PNG("./Figs/bar-plt1.png", 6inch, 6inch), myplot1)
myplot1
```

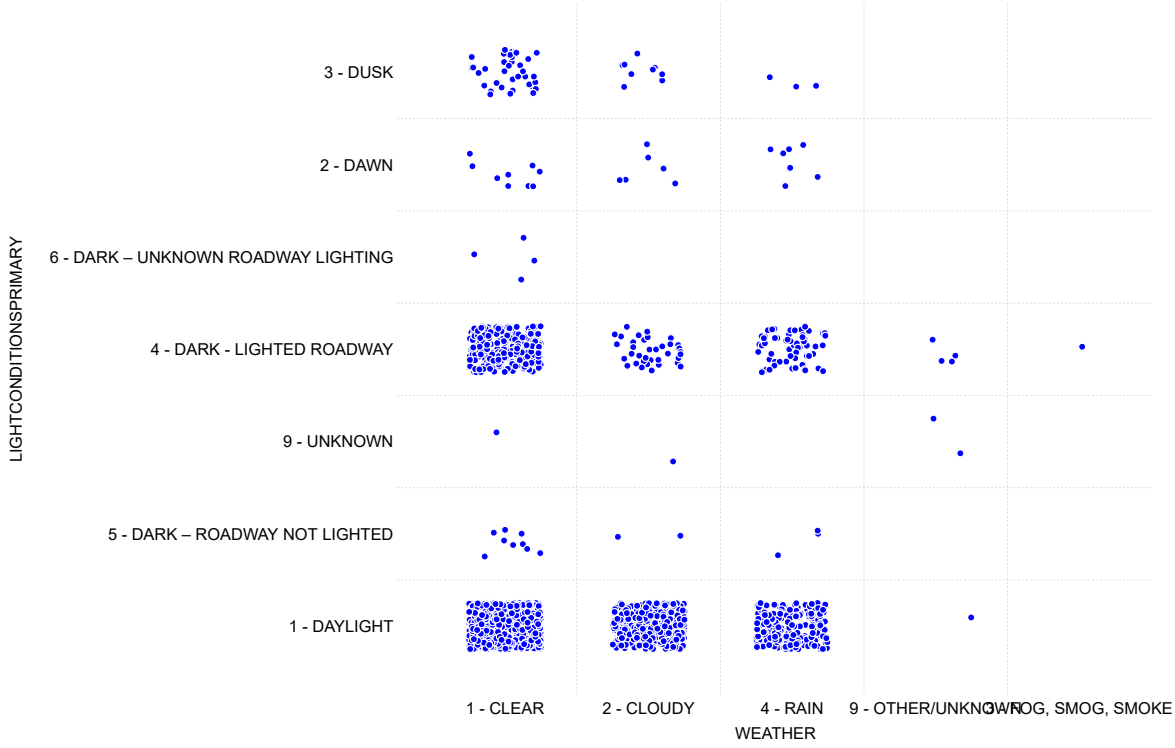
Out[17]:



Q 13: Generate a scatter plot between weather and light conditions. State which combinations of weather and light conditions appear to have significantly higher number of crashes. Please use set_default_plot_size(12inch, 8inch) function to adjust the figure size as needed for visibility.

In [18]:
```
set_default_plot_size(12inch,8inch)
myplot2 = Gadfly.plot(new_data_nomissing, x = "WEATHER", y="LIGHTCONDITIONSPRIMARY",
draw(PNG("./Figs/scatter-plt1.png", 6inch, 6inch), myplot2)
myplot2
```

Out[18]:

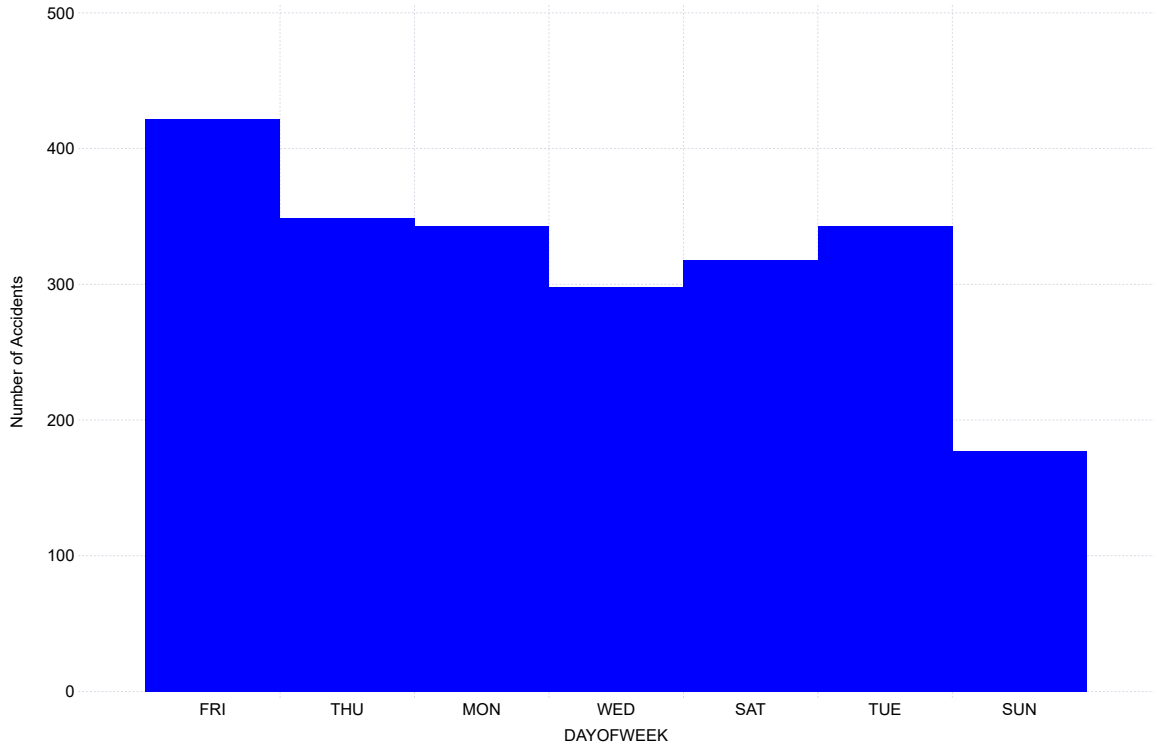


Weather conditions of clear and light conditions of dark lighted road have most number of crashes followed by clear-daylight and cloudy-daylight.

Q 14: Generate a plot to view the number of crashes on different days of the week. On which day of the week do fewer crashes happen? On which day of the week do the highest number of crashes happen?

In [19]:
```
set_default_plot_size(12inch,8inch)
myplot3 = Gadfly.plot(new_data_nomissing, x = "DAYOFWEEK", Geom.histogram, Guide.yla
draw(PNG("./Figs/bar-plt2.png", 6inch, 6inch), myplot3)
myplot3
```

Out[19]:

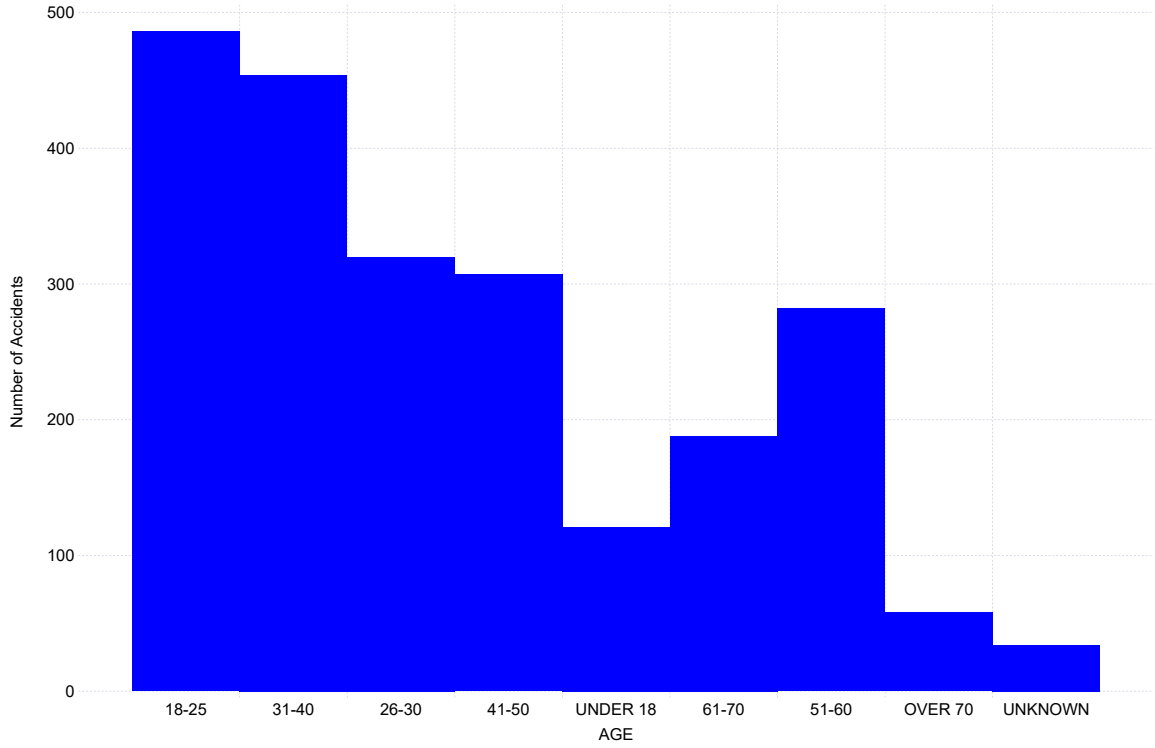


There are fewer crashes on Sunday, as it seems to be last day of weekend so maybe less people came out on streets. Most number of crashes are seen on Friday, it is the first day of weekend and more people seems to be on street.

Q 15: Generate a plot to view the number of crashes reported per age-group. Which age group is involved in the most number of crashes?

In [20]:
```
set_default_plot_size(12inch,8inch)
myplot4 = Gadfly.plot(new_data_nomissing, x = "AGE", Geom.histogram, Guide.ylabel("N
draw(PNG("./Figs/scatter-plt1.png", 6inch, 6inch), myplot4)
myplot4
```

Out[20]:



Age group of 18-25 is involved in most number of the crashes.

Q 16: Load the "iris" dataset using the following command.

iris = dataset("datasets", "iris");

This dataset has information about flowers from three plant species.

Do:

1. List attributes in this data
2. Generate a scatter plot between "PetalLength" and "PetalWidth" where each point is colored based on "Sepecies". What observations can you make about the flowers from the three plant species based on this plot.

In [21]:
```
iris = dataset("datasets", "iris");
```

```
WARNING: Method definition unix2zdt(Real) in module TimeZones at /users/PES0801/shar
mahl/.julia/v0.6/TimeZones/src/conversions.jl:122 overwritten in module RData at /us
ers/PES0801/sharmahl/.julia/v0.6/RData/src/convert.jl:201.
```

In [22]:
```
describe(iris[:, :])
```

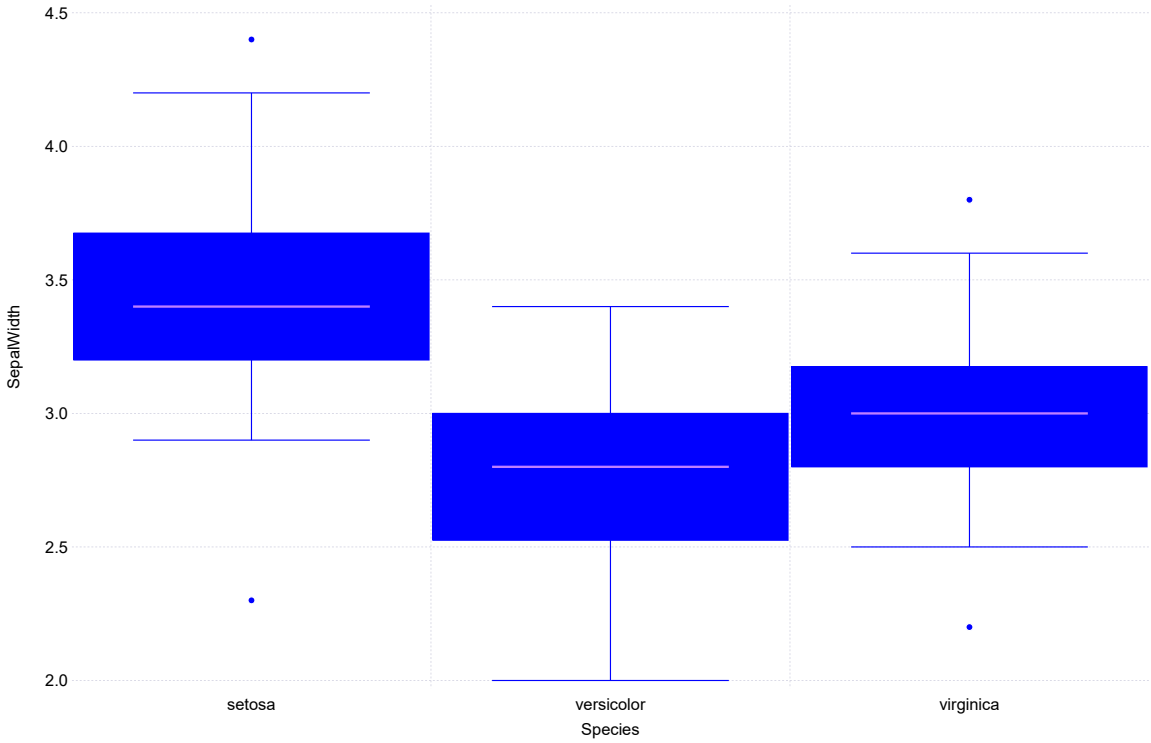
Out[22]:

	variable	mean	min	median	max	nunique	nmissing	elty
1	SepalLength	5.84333	4.3	5.8	7.9			Floa
2	SepalWidth	3.05733	2.0	3.0	4.4			Floa
3	PetalLength	3.758	1.0	4.35	6.9			Floa
4	PetalWidth	1.19933	0.1	1.3	2.5			Floa
5	Species					3		CategoricalArrays.CategoricalString{UIn

Q 17: Using Iris dataset, generate a box plot to compare the SepalWidth for the three plant species. Flowers from which species has generally longer sepalwidths?

In [23]:
```
set_default_plot_size(12inch,8inch)
myplot5 = Gadfly.plot(iris, x = "Species", y="SepalWidth", Geom.boxplot, white_panel
draw(PNG("./Figs/scatter-plt1.png", 6inch, 6inch), myplot5)
myplot5
```

Out[23]:

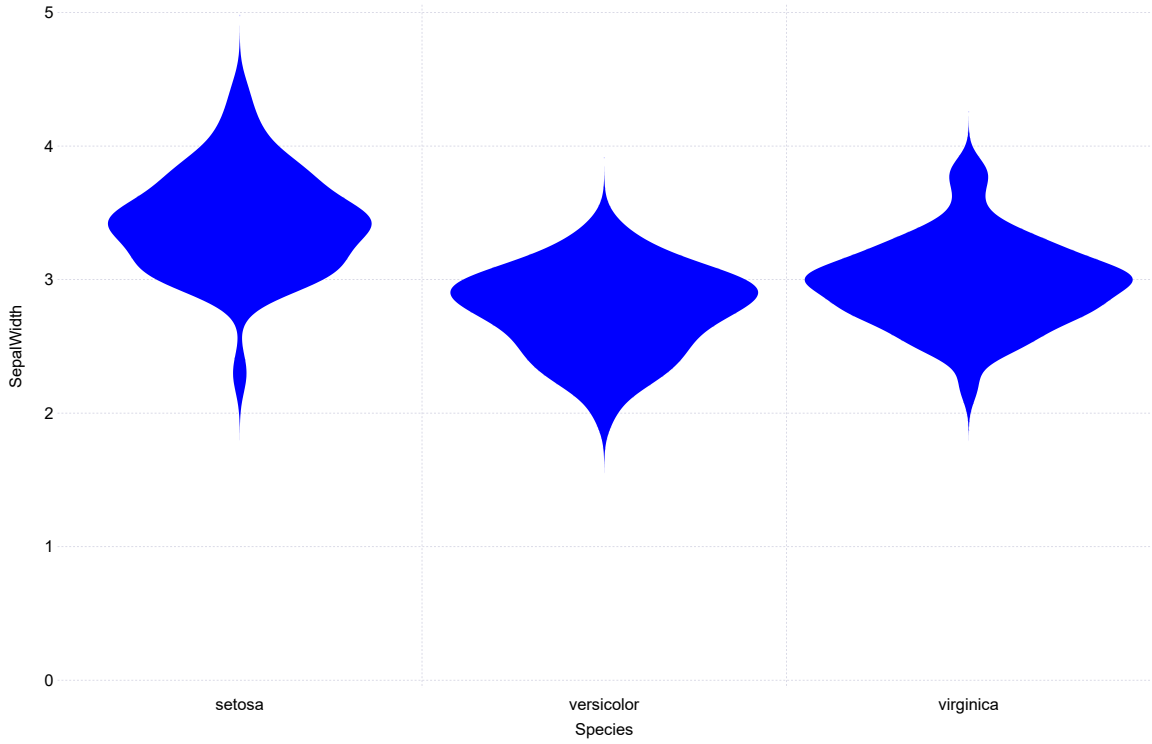


Flowers from Setosa have larger SepalWidths

Q 18: Using Iris dataset, generate a violin plot for SepalWidth (similar to the box plot above). What new observations can you make from this plot, compared to the box plots you generated in response to **Q 17**.

In [24]:
```
set_default_plot_size(12inch,8inch)
myplot6 = Gadfly.plot(iris, x = "Species", y = "SepalWidth", Geom.violin, white_pane
draw(PNG("./Figs/scatter-plt1.png", 6inch, 6inch), myplot6)
myplot6
```

Out[24]:



SepalWidth for Setosa are larger than the other species. We also get to know that majority of the flowers for Setosa have sepalwidths around 3.5, for versicolor it is around 2.8-3 and lastly for virginica it is around 3.