STAT 527 HW 2

Satoshi Ido (ID: 34788706)

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1
(10 points) According to Newton's universal law of gravitation,
the acceleration of an object in the direction of the sun due to the sun's gravity can be written in the form

$$a = \frac{1}{r^2}$$

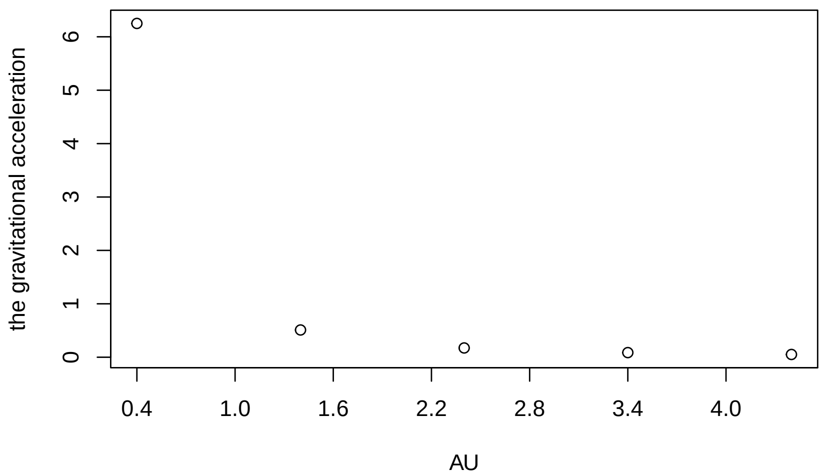
Here, r is the distance of the object from the sun's center, in astronomical units (AU) of distance. One AU is the average distance of the Earth from the sun, about 150 million kilometers. The units of a are scaled for convenience in this version of Newton's equation so that one unit of acceleration is experienced at a distance of 1AU. Use the equation to calculate the gravitational accelerations at each of the planets' average distances from the sun:

```
Mercury <- 1 / (0.39)^2
Venus <- 1 / (0.723)^2
Mars <- 1 / (1.524)^2
Jupiter <- 1 / (5.203)^2
Saturn <- 1 / (9.539)^2
Uranus <- 1 / (19.18)^2
Neptune <- 1 / (30.06)^2
Pluto <- 1 / (39.53)^2
a <- c(Mercury, Venus, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto)
# the gravitational accelerations at each of the planets' average distances from the sun
print(a)
```

```
## [1] 6.5746219592 1.9130371569 0.4305564167 0.0369396136 0.0109899142
## [6] 0.0027183339 0.0011066800 0.0006399505
```

2
(10 points) Using the equation from Question 1, draw a graph of the gravitational acceleration (vertical axis) versus a range of values of r ranging from around 0.4AU (distance of Mercury) to around 5.2AU (distance of Jupiter). According to Newton's gravitational law, is there any distance at which the sun's gravity is escaped entirely?

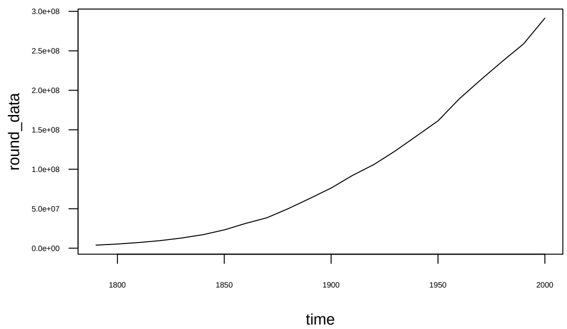
```
r <- 0.4:5.2
a <- 1 / r^2
plot(r, a, xlab="AU", ylab="the gravitational acceleration", xaxp = c(0.4, 5.2, 8))
```

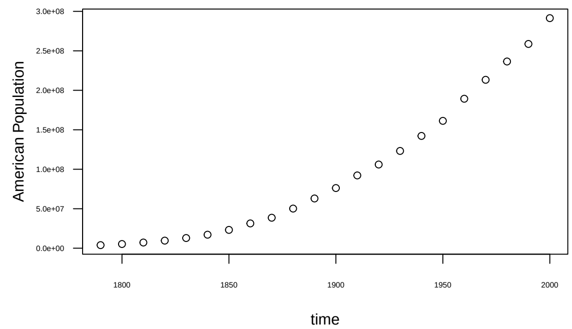


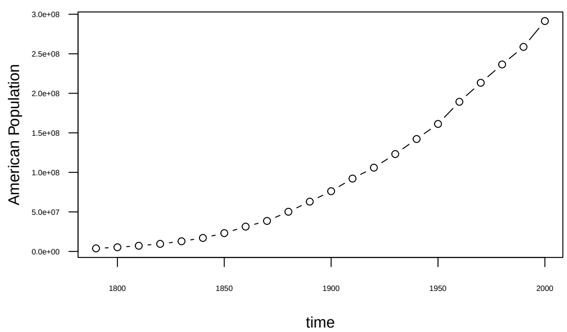

```
# if the distance = 0, the sun's gravity becomes 0, indirectly meaning it escaped entirely.
```

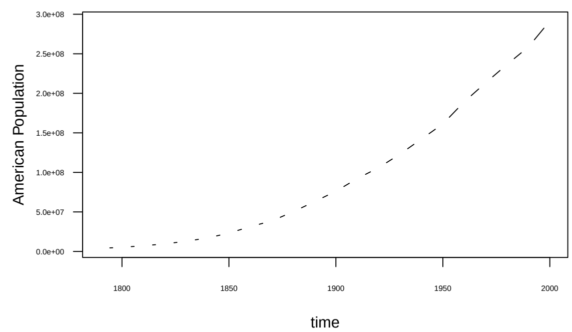
3
(10 points) The following (next page) are the population sizes of the United States through its entire history, according to the U.S. Census. Construct a line plot (type="I") of the U.S. population (vertical axis) versus time (horizontal axis). By the way, rounding the population sizes to the nearest 100,000 or so will hardly affect the appearance of the graph. Change the script and repeat the plot six more times (saving the graph each time), using type="p", type="b", type="C", type="o", type="h", and type="l". Compare the different graph types. What different aspects of the data are emphasized by the different graph types?

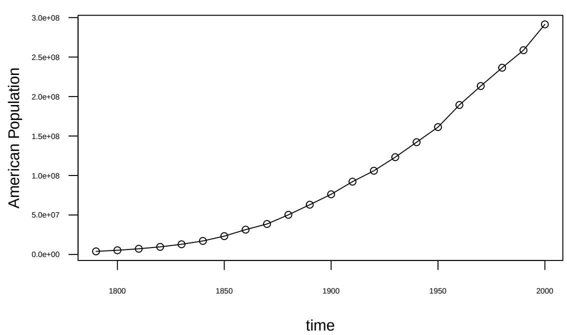
```
library("plyr")

data <- c(3929214, 5308483, 7239881, 9638453, 12860702, 17063353, 23191876, 31443321, 38558371, 50189209
            62979766, 76212168, 92228496, 106021537, 123202624, 142164569, 161325798, 189323175, 2133020
            236542199, 258709873, 291421906
        )
time <- seq(1790, 2000, 10)
round_data <- round_any(data, 100000)
# The line plot of of the U.S. population vs time
plot(time, round_data, type = "l", las = 1, cex.axis = 0.5)

# Compare with the different graph types
plot(time, round_data, type = "p",
    ylab = "American Population", las = 1, cex.axis = 0.5)
plot(time, round_data, type = "b",
    ylab = "American Population", las = 1, cex.axis = 0.5)
plot(time, round_data, type = "c",
    ylab = "American Population", las = 1, cex.axis = 0.5)
plot(time, round_data, type = "o",
    ylab = "American Population", las = 1, cex.axis = 0.5)
plot(time, round_data, type = "h",
    ylab = "American Population", las = 1, cex.axis = 0.5)
```

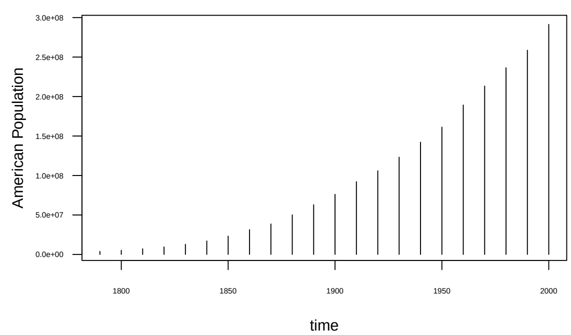













```
# The type "l" graph emphasizes a transition over time period.
    # In this problem, we want to know about the transition so I assume
    # that this type is the optimal.
# The type "p" graph emphasizes each data point over a transition.
    # If we want to pay attention to each data. This type can be an option.
# The type "b" graph is a hybrid of type "l" and "p".
    # We can see the smooth transition while we can understand each point.
# The type "c" graph shows the data point with different design.
    # We would use this type graph when we want to display multiple graphs
    # in the same plot in order to make distinct from other graph.
# The type "o" graph is similar to type "b" and has a similar effect as well.
# The type "h" graph is useful when we want to display the vertical lines.
    # If we want to display a negative value in the plot, it would be this type to use.
```