Stevens's Power Law

Visual perception

15 marks

Stevens's Power Law

a. **(3 marks)** The following (incomplete) function determines how the ratio (`x/y`) of two **actual** stimulus values (`x` and `y`) would be **perceived** according to Stevens's power law. It returns the perceived value of the ratio.

   The first few lines provide error checking on argument values. Note that only the value `x` need be supplied; the remaining arguments have default values. Note also either `x`, or `y`, or both could be a vector; `beta` cannot.

   i. *(2 marks)* Complete the `stevensRatio()` function above.

   Show your code.

```r
stevensRatio <- function(x, y = 1, beta = 1) {
    if(missing(x))  stop("Must supply a non-negative value for x")
    if(any(x < 0))  stop("Must have x >= 0")
    if(any(y <= 0)) stop("Must have y > 0")
    if(beta <= 0)   stop("Must have beta > 0")
    #
    # You need to insert code here to complete the function
    #
   x^beta
}
```

   ii. *(1 mark)* Execute your code for the ratios 0.5 and 2.0 when $\beta = 0.7$. (Note: these were considered in class. Check that you get the same answers as in class.)

   Show the code and the results **for both cases**

```r
stevensRatio(0.5,1,0.7)
```

```
## [1] 0.6155722
```

```r
stevensRatio(2,1,0.7)
```

```
## [1] 1.624505
```

b. **(7 marks)** One visual representation frequently used to encode magnitude is **length** (i.e. the length of a straight line segment).

   According to Stevens's law, the perceived magnitude of length is proportional to a power β of the actual length with $0.9 \leq \beta \leq 1.1$.

   Here you will investigate the perception of length ratios $r = x/y$ for the two extremes $\beta = 0.9$ and $\beta = 1.1$.

   To this end, use the ratio

```
r <- seq(from = 0.1, to = 5, by = 0.1)
# from which you can construct the limit
lim <- extendrange(r)
```

and your function `stevensRatio()` for the following.

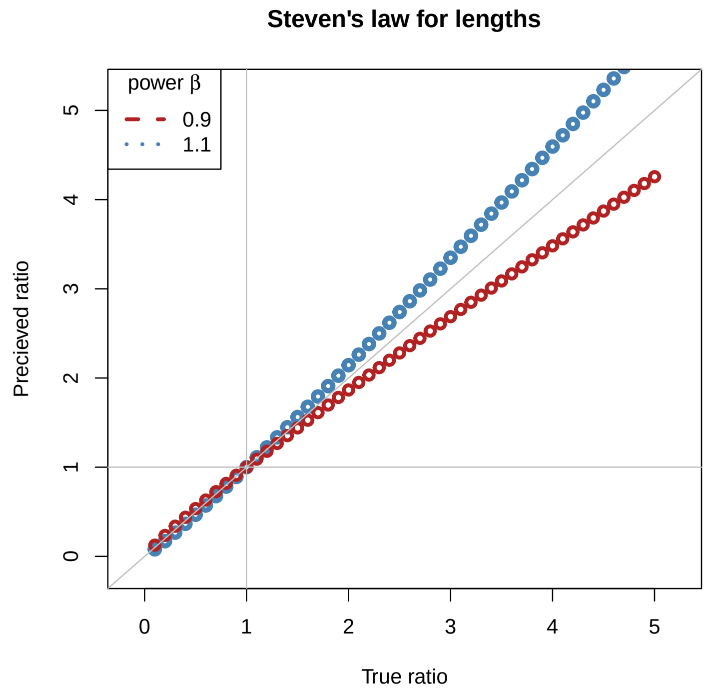
Construct a scatterplot showing both curves together and make sure that it has **exactly having the following characteristics**.

```
- the plot limits \code{xlim} and \code{ylim} should both have value \code{lim} (see above)
- the main plot title should be "Stevens's law for lengths"
- the $x$ axis should be labelled "True ratio"
- the $y$ axis should be labelled "Perceived ratio"
- the curve for $\beta = 0.9$ should be of colour \code{col = "firebrick"} and have line type \code{l
- the curve for $\beta = 1.1$ should be of colour \code{col = "steelblue"} and have line type \code{l
- there should be three solid (no dashing) \code{"grey"} coloured straight lines

  - a vertical one at $x = 1$,
  - a horizontal one at $y = 1$, and
  - a diagonal one at $y = x$
  - all having line width 1

- the following legend (should match the description above)
```

i. *(4 marks)* Show the code (including the legend) used to construct the scatterplot. **Also** show the resulting scatterplot itself.

   NOTE Use the following RMarkdown variable values in the header for your R code that produces the plot.

```
prec_1 = stevensRatio(r, 1, 1.1)
prec_2 = stevensRatio(r, 1, 0.9)
plot(r, prec_1,xlim = lim, ylim=lim,main = "Steven's law for lengths", xlab = "True ratio",
     ylab="Precieved ratio", col="steelblue", lty=3, lwd=4)
points(r,prec_2,col="firebrick", lty=2, lwd=3)
legend("topleft",
       legend = c("0.9", "1.1"),
       lty = c(2, 3), lwd = 3,
       col = c("firebrick", "steelblue"),
       title = expression(paste("power ", beta)))

abline(h=1,col="grey", lwd=1)
abline(v=1,col="grey", lwd=1)
abline(0,1,col="grey", lwd=1)
```



ii. *(3 marks)* What do you conclude about the possible perception of the length ratios when the true ratio is greater than 1? Explain your reasoning.

given true ratio>1, if $\beta > 1$, the perception of length ratio is larger than the true ratio of length.
if $\beta < 1$, the perception of length ratio is smaller than the true ratio of length.

Moreover, as true ratio increase, the difference between perceptual ratio and true ratio increase

this is because at a fixed true ratio=x>1, the perceived ratio when $\beta > 1$ is larger than true ratio (line y=x), which is larger than perceived ratio when $\beta < 1$

Also, distance between red/blue dots and line y=x increase as true ratio increase. which suggests less accuracy in perception.

c. **(5 marks)** Two other ways to visualize magnitude are to use area and volume. As in part (b) above, use your `stevensRatio()` function to produce a scatterplot having the following characteristics:

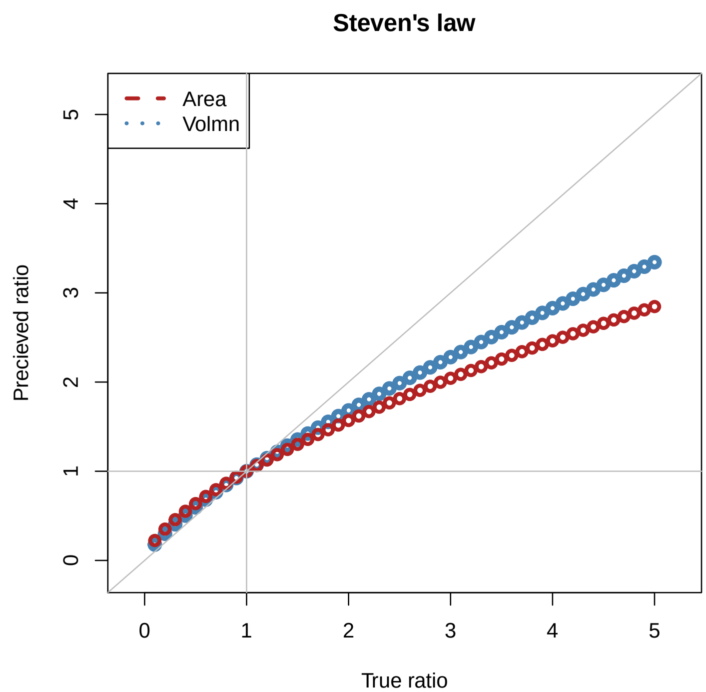
- the plot limits `xlim` and `ylim` should both have value `lim` (see part b. above)
- the main plot title should be "Stevens's law"
- the x axis should be labelled "True ratio"
- the y axis should be labelled "Perceived ratio"
- the curve for area should be of colour `col = "firebrick"` and have line type `lty = 2` and line width `lwd = 3`
- the curve for volume should be of colour `col = "steelblue"` and have line type `lty = 3` and line width `lwd = 4`
- there should be three solid (no dashing) `"grey"` coloured straight lines
  - a vertical one at $x = 1$,
  - a horizontal one at $y = 1$, and
  - a diagonal one at $y = x$

- all having line width 1

- there should be a legend appropriately identifying the curves for area (use the word "area") and volume (use the word "volume").
- in each case, use the middle of the range of β values that have been determined experimentally (see slides).

i. *(2 marks)* Produce the scatterplot and show the code used.

```
prec_1 = stevensRatio(r, 1, 0.75)
prec_2 = stevensRatio(r, 1, 0.65)
plot(r, prec_1,xlim = lim, ylim=lim,main = "Steven's law", xlab = "True ratio",
     ylab="Precieved ratio", col="steelblue", lty=3, lwd=4)
points(r,prec_2,col="firebrick", lty=2, lwd=3)
legend("topleft",
       legend = c("Area", "Volmn"),
       lty = c(2, 3), lwd = 3,
       col = c("firebrick", "steelblue"),
       )

abline(h=1,col="grey", lwd=1)
abline(v=1,col="grey", lwd=1)
abline(0,1,col="grey", lwd=1)
```




```
ii. *(2 marks)* What do you conclude about the use of area or volume when the true ratio is greater t
```

the ratio of area/volumn of objects seems smaller than the true ratio. This is because when true ratio=x>1, the percieved ratio is under the line y=x, which implies precieved ratio being smaller than true ratio.

```
iii. *(1 mark)* How does using area or volume compare to using length to encode magnitude?   Explain y
```

it's less accurate to encode magnitude using area/volumn than using length. This is because if we are decoding the ratio of area/volumn to unit area/volumn, the precieved ratio is further from true ratio than if we are using length, and the difference increase as true ratio increase.