

Quiz 7

```
age <- c(288,228,240,384,264,247,253,324,240,288,262,257,260,361,252)
row <- c(rep("1",3), rep("2",3), rep("3",3), rep("4",3), rep("5",3))
as.factor(row)

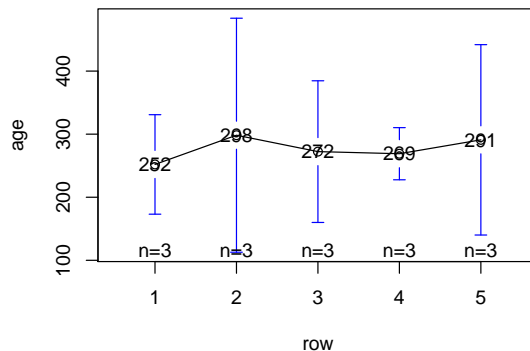
## [1] 1 1 1 2 2 2 3 3 3 4 4 4 5 5 5
## Levels: 1 2 3 4 5

class.data <- rbind(age,row)
lm.fit <- lm(age~row)
```

Above is the age row data we collected in class on Wednesday. Answer the following questions.

1. Is this a balanced design?
2. Refer to the plot below.
 - (a) What was the average age of students in row 3? List the average age of students for each row.
 - (b) Which row had the largest spread of ages?

```
require(gplots)
plotmeans(age~row, mean.labels = T, digits = 2)
```



3. I fit a linear model and below is a summary of the model.

```
summary(lm.fit)

##
## Call:
## lm(formula = age ~ row)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -51.3   -31.7   -12.0    27.5    85.7
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    252.0      29.0     8.70  5.6e-06 ***
## row2           46.3      41.0     1.13    0.28
## row3           20.3      41.0     0.50    0.63
## row4           17.0      41.0     0.41    0.69
## row5           39.0      41.0     0.95    0.36
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 50.2 on 10 degrees of freedom
## Multiple R-squared:  0.139, Adjusted R-squared:  -0.205
## F-statistic: 0.405 on 4 and 10 DF,  p-value: 0.801
```

4. Refer to 2(a) where you listed the average age of students for each row. Can you find these numbers in the output above? Hint: you may have to do some arithmetic. Show, specifically, how to use the output to get to each of the row averages.
5. State the hypotheses for conducting a one-way ANOVA for these data.
6. The anova is below. What is the F-statistic and the p-value?

```
anova(lm.fit)

## Analysis of Variance Table
##
## Response: age
##           Df Sum Sq Mean Sq F value Pr(>F)
## row         4   4082     1021    0.41   0.8
## Residuals  10  25193     2519
```

7. What is your decision at a significance level of 0.05?

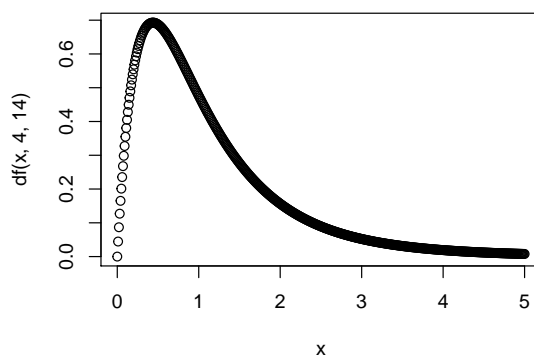
8. What is your conclusion?

9. It turns out that the F-statistic follows an F-distribution with 4 and 10 degrees of freedom under the null hypotheses. The F-distribution is similar to the t-distribution in that if I ask:

What is the distribution of the F-statistic under the null hypothesis?

It is not enough to say “the F-distribution”. You should say “the F-distribution with 4 and 10 degrees of freedom”. This is because the F-distribution changes when the degrees of freedom changes. Note the degrees of freedom are found in the df column in the ANOVA table above.

The plot below shows the F distribution with 4 and 10 degrees of freedom. Draw a long vertical line at your F-statistic. Shade the area that is your p-value. Note that F-tests are always upper tailed.



10. Does the shaded area appear to be consistent with the p-value given in the ANOVA?

Let's look at a new dataset. Cuckoos are known to lay their eggs in the nests of other (host) birds. The eggs are then adopted and hatched by the host birds. These data were originally collected by O. M. Latter in 1902 to see how the size of a cuckoo egg is related to the species of the host bird.

11. What parameterization of the ANOVA model does the following code create?

```
fit.bird <- lm(length~species, data = cuckoo)
```

- (a) Cell Means
- (b) Reference Coded

12. Use the following output to write the estimated mean egg size for the hedge sparrow and the tree pipet.

```
summary(fit.bird)

##
## Call:
## lm(formula = length ~ species, data = cuckoo)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.6489 -0.4489 -0.0489  0.5511  2.1511
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      23.1214     0.2430   95.15 < 2e-16
## speciesmeadow pipet  -0.8225     0.2783   -2.96  0.0038
## speciespied wagtail  -0.2181     0.3379   -0.65  0.5199
## speciesrobin        -0.5464     0.3328   -1.64  0.1033
## speciestree pipet    -0.0314     0.3379   -0.09  0.9261
## specieswren         -1.9914     0.3379   -5.89  3.9e-08
##
## Residual standard error: 0.909 on 114 degrees of freedom
## Multiple R-squared:  0.313, Adjusted R-squared:  0.283
## F-statistic: 10.4 on 5 and 114 DF, p-value: 3.15e-08
```

- Hedge Sparrow:

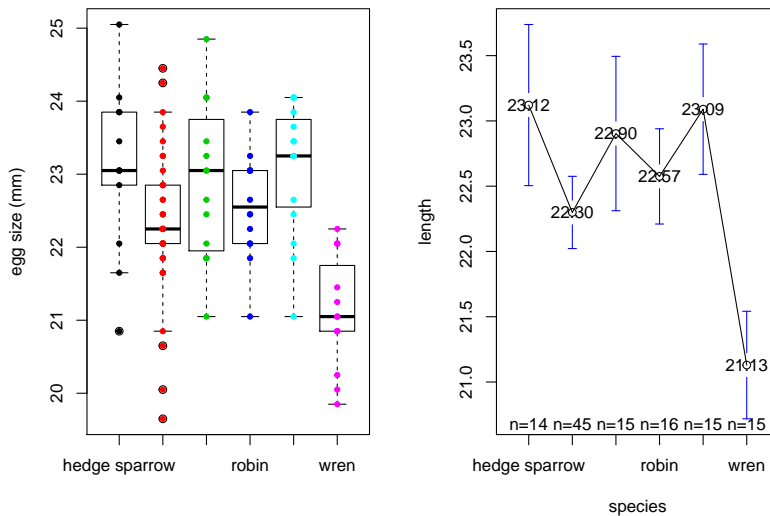
- Tree Pipet:

13. Below are boxplots for the egg size (mm) for all species of host birds, an effects plot and summary statistics for each host species.

```
names(cuckoo)

## [1] "length" "species"

par(mfrow = c(1,2))
boxplot(length~species, data = cuckoo, ylab = "egg size (mm)")
points(length~species, data = cuckoo, col = as.numeric(species), pch = 20)
#install.packages("gplots")
require(gplots)
plotmeans(length ~species, data = cuckoo, mean.labels = T, digits = 2)
```



```
favstats(length~species, data = cuckoo)
```

##	.group	min	Q1	median	Q3	max	mean	sd	n	missing
## 1	hedge sparrow	20.85	22.90	23.05	23.85	25.05	23.12	1.0687	14	0
## 2	meadow pipet	19.65	22.05	22.25	22.85	24.45	22.30	0.9206	45	0
## 3	pied wagtail	21.05	21.95	23.05	23.75	24.85	22.90	1.0676	15	0
## 4	robin	21.05	22.05	22.55	23.05	23.85	22.57	0.6846	16	0
## 5	tree pipet	21.05	22.55	23.25	23.75	24.05	23.09	0.9014	15	0
## 6	wren	19.85	20.85	21.05	21.75	22.25	21.13	0.7437	15	0

14. TRUE or FALSE: This a balanced design (circle one).

15. State the hypotheses for conducting a one-way ANOVA for these data

$H_0 :$

$H_a :$

16. The ANOVA is below.

```
## Analysis of Variance Table
##
## Response: length
##           Df Sum Sq Mean Sq F value    Pr(>F)
## species      5   42.9     8.59    10.4 3.2e-08 ***
## Residuals 114   94.2     0.83
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

17. What is the distribution of the F statistic under H_0 ?

18. What is the F statistic and corresponding p-value?

19. Which of the following is true about the F-statistic?

- A. The F-statistic is small because the variation in average egg size across bird type is large compared to the variation in the egg sizes within a bird type.
- B. The F-statistic is large because the variation in average egg size across bird types is large compared to the variation in the egg sizes within a bird type.
- C. The F-statistic is large because the variation in average egg size across bird types is small compared to the variation in the egg sizes within a bird type.

20. What is your conclusion?