hw1

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Question A

Please see all the missing values in the analysis of variance table below. The **Total Degree of Freedom** is **21**

```
library(reshape2)
library(dplyr)

Control = c(0.53, 0.36, 0.2, -0.37,-0.6, -0.64,-0.68,-1.27)
Knees = c(0.73, 0.31, 0.03, -0.29, -0.56, -0.96, -1.61, NA)
Eyes = c(-0.78, -0.86, -1.35, -1.48, -1.52, -2.04, -2.83, NA)
raw_data = data.frame(cbind(Control,Knees, Eyes))%>%melt()
colnames(raw_data) = c('Treatment', 'Phase Shift(h)')

model = aov(raw_data$`Phase Shift(h)`~raw_data$Treatment)
summary(model)
```

```
##                      Df Sum Sq Mean Sq F value  Pr(>F)
## raw_data$Treatment   2   7.224   3.612   7.289 0.00447 **
## Residuals           19   9.415   0.496
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 2 observations deleted due to missingness
```

Question B

```
x = model.tables(model, type = 'mean')
u1 = x$tables$`raw_data$Treatment`[1]
u2 = x$tables$`raw_data$Treatment`[2]
u3 = x$tables$`raw_data$Treatment`[3]
```

u1 is the the mean of phase shift in **Control** group, which is `-0.30875`. **u2** is the the mean of phase shift in **Knees** group, which is `-0.3357143`. **u3** is the mean of phase shift in **Eyes** group, which is `-1.5514286`.

Question C

The **null hypothesis** is all three populations have the same mean: **u1 = u2 = u3**. The **alternative hypothesis** is that **the population means are not all equal**

(i) Under the H0, the F-test statistic has an **F statistic: 7.289**

(ii) The p-value of the ANOVA F-test is **0.00447**

```
TukeyHSD(x = model, conf.level = 0.95)
```

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = raw_data$`Phase Shift(h)` ~ raw_data$Treatment)
##
## $`raw_data$Treatment`
##                       diff        lwr         upr      p adj
## Knees-Control -0.02696429 -0.9525222   0.8985936 0.9969851
## Eyes-Control  -1.24267857 -2.1682364  -0.3171207 0.0078656
## Eyes-Knees    -1.21571429 -2.1716263  -0.2598022 0.0116776
```

(iii) Based on the p-value from the F-test, we can reject the null hypothesis, which means that the population means of thress treatment are not the same. Based on the pair-wise comparison, I find that light treatment on eyes can affect the phase shift, whereas light treatment on knees failed to affect phase shift.