1.1.) a) Fit the model:

>h0 <- lm (total ~ takers + ratio + salary, sat)

All the three predictors have significant coefficients. The model fits well as the R-squared is over 0.8. While the takers and ratio variables are negative correlated to sat total score, indicating that lower percentage of sat takers, lower pupil/teacher ratio and higher average annual salary of teachers might be related to higher sat total score.

```
Call:
lm(formula = total ~ takers + ratio + salary, data = sat)
Residuals:
    Min      1Q  Median      3Q     Max
-89.244 -21.485  -0.798  17.685  68.262
Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 1057.8982    44.3287  23.865   <2e-16 ***
takers        -2.9134     0.2282 -12.764   <2e-16 ***
ratio         -4.6394     2.1215  -2.187   0.0339 *
salary         2.5525     1.0045   2.541   0.0145 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 32.41 on 46 degrees of freedom
Multiple R-squared:  0.8239,      Adjusted R-squared:  0.8124
F-statistic: 71.72 on 3 and 46 DF,  p-value: < 2.2e-16
```

b)To test hypothesis $\beta_{salary}=0$, fit the model

```
>h0a<- lm (total ~ takers + ratio, sat)
>anova (h0, h0a)
Analysis of Variance Table
Model 1: total ~ takers + ratio + salary
Model 2: total ~ takers + ratio
  Res.Df   RSS Df Sum of Sq      F  Pr(>F)
1     46 48315
2     47 55097 -1   -6781.6 6.4566 0.01449 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

c) We found that the p-value < 0.05, so we reject the hypothesis $\beta_{salary}=0$

To test hypothesis $\beta_{takers} = \beta_{ratio} = \beta_{salary}=0$, fit the model

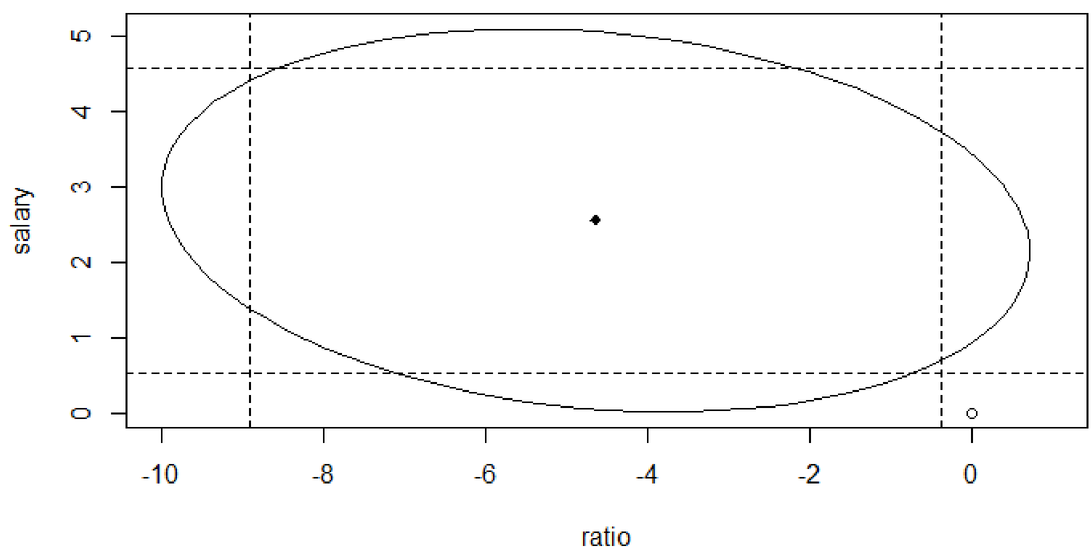
```
>h0b<-lm (total ~ 0, sat)
>anova(h0,h0b)
Analysis of Variance Table
Model 1: total ~ takers + ratio + salary
Model 2: total ~ 0
  Res.Df      RSS Df Sum of Sq     F    Pr(>F)
1     46    48315
2     50 46924380 -4 -46876065 11157 < 2.2e-16 ***
```

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
d)We found that the p-value < 0.05, so we reject the hypothesis $\beta_{takers} = \beta_{ratio} = \beta_{salary}=0$

2.)
>confint(h0,"salary",level=0.95)
```
          2.5 %       97.5 %
salary 0.5304797    4.574461
```
>confint(h0,"salary",level=0.99)
```
          0.5 %       99.5 %
salary -0.146684    5.251624
```

Because that the 99% CI includes 0, the p-value indicates non-significant , that is >0.01

3.) The joint confidence region for the parameters associated with ratio and salary is shown below:



The origin is located outside of the confidence region, so the hypothesis $\beta_{ratio} = \beta_{salary}=0$ is rejected.

4.) After adding expend to the model, the results are as follows:
```
>h1<-lm(total~expend+takers+ratio+salary,sat)
Call:
lm(formula = total ~ expend + takers + ratio + salary, data = sat)
Residuals:
    Min      1Q  Median      3Q     Max
-90.531 -20.855  -1.746  15.979  66.571
Coefficients:
            Estimate Std. Error t value Pr(>|t|)
```

```
(Intercept) 1045.9715    52.8698  19.784  < 2e-16 ***
expend        4.4626    10.5465   0.423    0.674
takers       -2.9045     0.2313 -12.559 2.61e-16 ***
ratio        -3.6242     3.2154  -1.127    0.266
salary        1.6379     2.3872   0.686    0.496
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 32.7 on 45 degrees of freedom
Multiple R-squared:  0.8246,	Adjusted R-squared:  0.809
F-statistic: 52.88 on 4 and 45 DF,  p-value: < 2.2e-16
```

The model is still significant, the coefficients of the ratio and salary changed a lot. The coefficients of takers remains significant. The goodness of fit is almost the same compared to the model in question 1.

5.) >h1a<-lm(total~takers,sat)

```
> anova(h1,h1a)
Analysis of Variance Table
Model 1: total ~ expend + takers + ratio + salary
Model 2: total ~ takers
  Res.Df   RSS Df Sum of Sq      F  Pr(>F)
1     45 48124
2     48 58433 -3    -10309 3.2133 0.03165 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

The hypothesis $\beta_{salary} = \beta_{expend} = \beta_{ratio} = 0$ is rejected.
Based on my entire analysis, I feel the salary may have an effect on the response.

2.

TSS-total sum of squares RSS-residual sum of squares p=number of predictors
n-number of observations

$$F = \frac{(TSS - RSS)/(p-1)}{RSS/(n-p)}$$

$$R^2 = 1 - \frac{RSS}{TSS} = \frac{TSS - RSS}{TSS}$$

$$R^2 = 1 - \left(1 + F \cdot \frac{p-1}{n-p}\right)^{-1}$$