#2. SAS code:

```
proc glm  data = trout;
      title "Problem 2 Analysis: Hemoglobin & Code";
   class code;
   model hemoglobin = code;
   lsmeans code / cl;
   contrast "Contrast 1" Code 1 -1 0 0;
   contrast "Contrast 2" Code 0 -1 1 0;
run;
```

Output (exercepted):

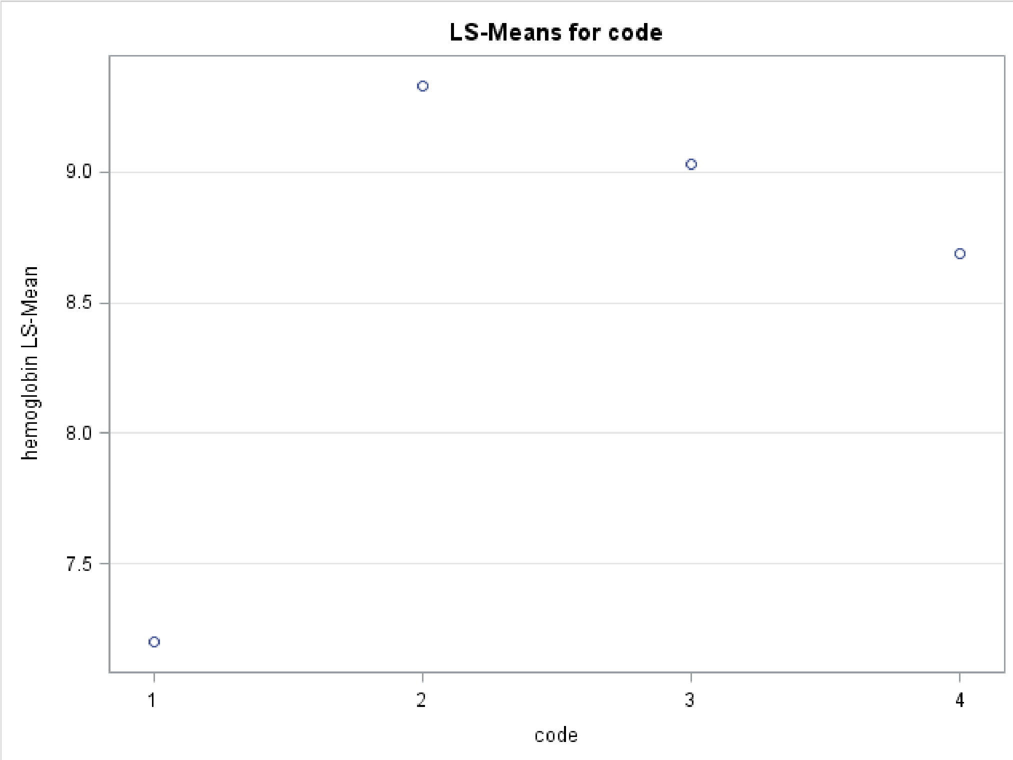
Problem 2 Analysis: Hemoglobin & Code

The GLM Procedure

Dependent Variable: hemoglobin

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	26.80275000	8.93425000	5.70	0.0027
Error	36	56.47100000	1.56863889		
Corrected Total	39	83.27375000			

code	hemoglobin LSMEAN	95% Confidence Limits	
1	7.200000	6.396752	8.003248
2	9.330000	8.526752	10.133248
3	9.030000	8.226752	9.833248
4	8.690000	7.886752	9.493248



Problem 2 Analysis: Hemoglobin & Code

The GLM Procedure

Dependent Variable: hemoglobin

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
Contrast 1	1	22.68450000	22.68450000	14.46	0.0005
Contrast 2	1	0.45000000	0.45000000	0.29	0.5955

#3. SAS code:

```
proc glm  data = batteries;
      title "Problem 3 Analysis:  Battery life and brand and temperature";
      class brand temperature;
      model life = brand|temperature;
      lsmeans brand|temperature / cl;
      contrast "Redundant contrast?" brand*temperature 1 -1 -1 1;
      contrast "Contrast 3" brand 1 -1;
      contrast "Contrast 4" temperature 1 -1;
      run;
```

Output (excerpted):

Problem 3 Analysis: Battery life and brand and temperature

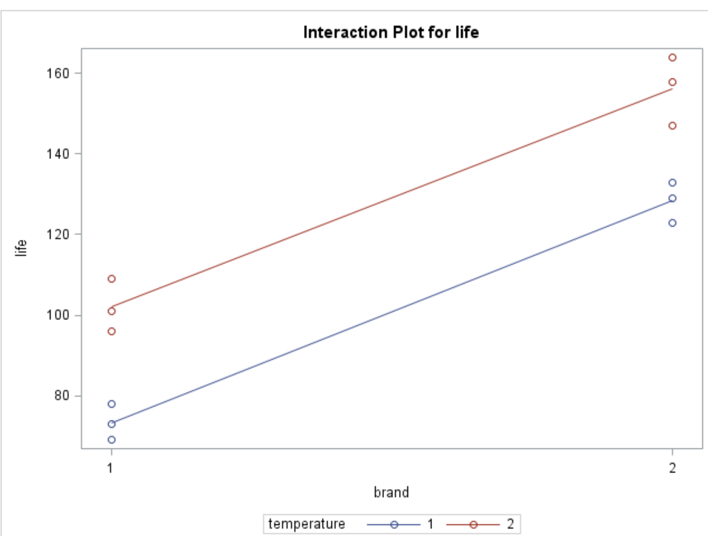
The GLM Procedure

Dependent Variable: life

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	11374.00000	3791.33333	93.04	<.0001
Error	8	326.00000	40.75000		
Corrected Total	11	11700.00000			

R-Square	Coeff Var	Root MSE	life Mean
0.972137	5.550933	6.383573	115.0000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
brand	1	8965.333333	8965.333333	220.01	<.0001
temperature	1	2408.333333	2408.333333	59.10	<.0001
brand*temperature	1	0.333333	0.333333	0.01	0.9302



Problem 3 Analysis: Battery life and brand and temperature

The GLM Procedure
Least Squares Means

brand	life LSMEAN
1	87.666667
2	142.333333

temperature	life LSMEAN
1	100.833333
2	129.166667

...

Problem 3 Analysis: Battery life and brand and temperature

The GLM Procedure

Dependent Variable: life

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
Test contrast	1	0.333333	0.333333	0.01	0.9302
Contrast 3	1	8965.333333	8965.333333	220.01	<.0001
Contrast 4	1	2408.333333	2408.333333	59.10	<.0001

R Code and Output

#2

```
### Problem 2 ###
> setwd("C:/Users/Melissa/Dropbox (Personal)/STA 674/exam 2") #Path
> library(multcomp)
> library(emmeans)
> hemoglobin = read.csv("hemoglobin.csv", header = T)
>
> Code = as.factor(hemoglobin$Code)
> Hemoglobin = hemoglobin$Hemoglobin
> Hemoglobin = data.frame(Code,Hemoglobin)
>
> #Part b
> model_2 = lm(Hemoglobin~Code-1, data = Hemoglobin)
> anova(model_2)
Analysis of Variance Table

Response: Hemoglobin
          Df  Sum Sq Mean Sq F value    Pr(>F)
Code       4 2959.46  739.86  471.66 < 2.2e-16 ***
Residuals 36   56.47    1.57
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
>
> #Part c
> model_2c = lm(Hemoglobin~Code, data = Hemoglobin)
> code_ls = lsmeans(model_2c, ~(Code))
>
> code_ls
 Code lsmean    SE df lower.CL upper.CL
 1      7.20 0.396 36     6.40     8.00
 2      9.33 0.396 36     8.53    10.13
 3      9.03 0.396 36     8.23     9.83
 4      8.69 0.396 36     7.89     9.49

Confidence level used: 0.95
>
> #Contrast 1
> L1 <- matrix(c(1,-1,0,0),1)
> L.1 <- glht(model_2,linfct=mcp(Code=L1))
> summary(L.1)

         Simultaneous Tests for General Linear Hypotheses

Multiple Comparisons of Means: User-defined Contrasts


Fit: lm(formula = Hemoglobin ~ Code - 1, data = Hemoglobin)

Linear Hypotheses:
       Estimate Std. Error t value Pr(>|t|)
1 == 0  -2.1300     0.5601  -3.803 0.000534 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
(Adjusted p values reported -- single-step method)

>
> #Contrast 2
> L2 <- matrix(c(0,-1,1,0),1)
> L.2 <- glht(model_2,linfct=mcp(Code=L2))
> summary(L.2)
```

```
        Simultaneous Tests for General Linear Hypotheses

Multiple Comparisons of Means: User-defined Contrasts


Fit: lm(formula = Hemoglobin ~ Code - 1, data = Hemoglobin)

Linear Hypotheses:
       Estimate Std. Error t value Pr(>|t|)
1 == 0  -0.3000     0.5601  -0.536    0.596
(Adjusted p values reported -- single-step method)
```

#3

```
### Problem 3 ###
> batterytemp = read.csv("batterytemp.csv", header = T)
>
> Brand = as.factor(batterytemp$Brand)
> Temp = as.factor(batterytemp$Temp)
> Minutes = batterytemp$Minutes
> Batterytemp = data.frame(Brand,Temp,Minutes)
>
>
> model_3 = lm(Minutes~Brand + Temp + Brand*Temp, data = Batterytemp)
> anova(model_3)
Analysis of Variance Table

Response: Minutes
           Df Sum Sq Mean Sq  F value    Pr(>F)
Brand       1 8965.3  8965.3 220.0082 4.203e-07 ***
Temp        1 2408.3  2408.3  59.1002 5.810e-05 ***
Brand:Temp  1    0.3     0.3   0.0082    0.9302
Residuals   8  326.0    40.7
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
>
> #Brand
> batt_brand = lsmeans(model_3, 'Brand')

> batt_brand
 Brand lsmean   SE df lower.CL upper.CL
 1       87.7 2.61  8     81.7     93.7
 2      142.3 2.61  8    136.3    148.3

Results are averaged over the levels of: Temp
Confidence level used: 0.95
>
> #Temp
> batt_temp = lsmeans(model_3, 'Temp')

> batt_temp
 Temp lsmean   SE df lower.CL upper.CL
 1       101 2.61  8     94.8      107
 2       129 2.61  8    123.2      135

Results are averaged over the levels of: Brand
Confidence level used: 0.95
>
> #Contrast3
> pairs(batt_brand)
 contrast estimate   SE df t.ratio p.value
```

```
 1 - 2       -54.7 3.69  8 -14.833 <.0001

Results are averaged over the levels of: Temp
> #Contrast4
> pairs(batt_temp)
 contrast estimate   SE df t.ratio p.value
 1 - 2       -28.3 3.69  8 -7.688  0.0001

Results are averaged over the levels of: Brand
```