1. There is high consumer demand for low-fat pork. Thus pork producers get paid more for lean hogs. Lean percentage is one measure of leanness used by hog buyers to price hogs. The higher the lean percentage the more valuable the hog. An experiment was conducted to determine if a feed additive called Paylean can significantly increase lean percentage. Eight pens containing six hogs each were used in the experiment. At the beginning of the experiment 4 pens were randomly selected to receive the Paylean treatment. The feed for each of these pens was supplemented with Paylean each day. The other four pens were given feed with no Paylean additive throughout the study. The lean percentage for each of the 48 hogs used in the experiment was recorded at the time of slaughter. The 48 lean percentages were used to produce the following ANOVA table.

Source	DF	Mean Square	Expected Mean Square
(i) treatment	??	186	$\sigma_d^2 + 6\sigma_e^2 + 24\theta_t^2$
(ii) ????????	??	10	$\sigma_d^2 + 6\sigma_e^2$
(iii)????????	??	5	σ_d^2
(iv) C. Total	??		

(a) What are the experimental units in this experiment?

PENS

(b) What are the observational units in this experiment?

Hogs

(c) Provide descriptive names for the labels missing from the SOURCE column.

i i. PENS (TREATMENT)

i ii. Hogs (Pens, Treatment)

(d) Provide the missing degrees of freedom.

i. $t-1 = 2-1 = 1$

ii. $t(r-1) = 2(4-1) = 6$

iii. $tr(n-1) = 2 \cdot 4 \cdot (6-1) = 40$

iv. $trn - 1 = 47$

(e) The average lean percentage of hogs in pens that received the Paylean additive was higher than the average lean percentage of hogs from the other pens. Is there evidence that the observed difference is statistically significant? Conduct a test to answer this question.

i. Compute a test statistic.

$$F_o = \frac{186}{10} = 18.6$$

ii. Give the degrees of freedom associated with the test statistic.

1 AND 6

iii. Write down a relevant value from the appropriate table.

$$F_{0.05,1,6} = 5.99$$

iv. Provide a short conclusion. (One sentence will do.)

THE AVERAGE LEAN PERCENTAGE OF HOGS IN PENS THAT RECEIVED THE PAYLEAN TREATMENT WAS SIGNIFICANTLY HIGHER THAN THE AVERAGE

(f) Estimate the variance among lean percentages of hogs within a pen. FOR HOGS IN CONTROL PENS.

$$\hat{\sigma}_d^2 = MS_{HOGS(PENS,TRT)} = 5$$

(g) Estimate the variance component associated with variation among pens treated alike.

$$\hat{\sigma}_e = \frac{MS_{PENS(TRT)} - MS_{HOGS(PEN,TRT)}}{6} = \frac{10-5}{6} = 0.8\overline{3}$$

2. Prolonged storage can lower the quality of grain. An experiment was conducted to gauge the effect of three factors on the quality of grain stored for 24 months. The three factors considered were preservative (present vs. absent), storage temperature (20° vs. 30° C), and humidity (low vs. high). Three containers of grain were randomly assigned to each combination of the levels of the three factors. Each container was independently treated with its assigned combination. One grain quality score was obtained for each container. SAS code and output for the analysis of the data are provided at the bottom of this page and continued on to the top of the next.

```
proc glm;
  class p h t;
  model y=p h t p*h p*t h*t p*h*t;
  lsmeans p*h*t / slice=h*t;
run;
```

```
The GLM Procedure
Dependent Variable: y
```

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	13187.24580	1883.89226	41.10	<.0001
Error	16	733.33392	45.83337		
Corrected Total	23	13920.57972			

Source	DF	Type I SS	Mean Square	F Value	Pr > F
p	1	3617.355162	3617.355162	78.92	<.0001
h	1	4552.797966	4552.797966	99.33	<.0001
t	1	1746.559636	1746.559636	38.11	<.0001
p*h	1	1363.913032	1363.913032	29.76	<.0001
p*t	1	1276.097257	1276.097257	27.84	<.0001
h*t	1	386.408517	386.408517	8.43	0.0104
p*h*t	1	244.114232	244.114232	5.33	0.0347

Least Squares Means

p	h	t	y LSMEAN
absent	high	20	55.2
absent	high	30	9.2
absent	low	20	83.4
absent	low	30	66.2
present	high	20	73.9
present	high	30	69.7
present	low	20	84.7
present	low	30	83.9

The researchers already know a lot about the effects of temperature and humidity on grain quality from past research. This experiment was conducted primarily to understand the effects of the preservative on grain quality at differing combinations of temperature and humidity. Conduct appropriate analyses and briefly summarize the results of your analyses to help the researchers understand how the preservative effects grain quality.

THERE IS SIGNIFICANT 3-FACTOR INTERACTION. THUS THE EFFECT OF THE PRESERVATIVE MIGHT BE DIFFERENT FOR EACH COMBINATION OF HUMIDITY AND TEMPERATURE. WE SHOULD TEST FOR A DIFFERENCE IN MEANS WITH AND WITHOUT PRESERVATIVE AT EACH COMBINATION OF HUMIDITY AND TEMP.

HUMIDITY	TEMP	TEST STATISTIC (COMPARE TO t WITH 16 df.)	2-SIDED PVALUE
HIGH	20	$(55.2-73.9)/\sqrt{\frac{45.83}{3}[1^2+(-1)^2]} = -3.38$	<0.01
HIGH	30	$(9.2-69.7)/\sqrt{\frac{45.83}{3}[1^2+(-1)^2]} = -10.94$	<0.001
LOW	20	$(83.4-84.7)/\sqrt{\frac{45.83}{3}[1^2+(-1)^2]} = -0.24$	>0.80
LOW	30	$(66.2-83.9)/\sqrt{\frac{45.83}{3}[1^2+(-1)^2]} = -3.20$	<0.01

THE PRESERVATIVE SIGNIFICANTLY INCREASES GRAIN QUALITY UNDER ALL CONDITIONS STUDIED EXCEPT WHEN HUMIDITY IS LOW AND TEMP IS 20°C. AT LOW HUMIDITY AND LOW TEMP QUALITY SCORES ARE HIGH WITH OR WITHOUT PRESERVATIVE.

3. Recall the paper airplane experiment conducted in class earlier this semester. We were interested in the effect of two factors on flight distance of paper airplanes. The factors were plane type (Dart vs. Flyer) and thrower which had 27 levels – one for each of the 27 students that participated in the experiment. Each student made and flew two planes of each type. The experiment was conducted in a completely randomized manner. SAS code and output are provided below.

```
proc glm;
  class plane thrower;
  model distance=plane thrower plane*thrower;
run;
```

The GLM Procedure

Dependent Variable: distance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	53	3464.289673	65.363956	1.73	0.0241
Error	54	2045.552083	37.880594		
Corrected Total	107	5509.841757			

Source	DF	Type I SS	Mean Square	F Value	Pr > F
plane	1	98.072595	98.072595	2.59	0.1134
thrower	26	1841.583076	70.830118	1.87	0.0264
plane*thrower	26	1524.634002	58.639769	1.55	0.0879

One of the students in our Stat 402 class suggested that there might have been a significant difference between the mean flight distance of planes thrown by women and the mean flight distance of planes thrown by men. The average flight distance of planes thrown by the 13 male participants was 22.43 feet. The average flight distance of planes thrown by the 14 female participants was 20.60 feet. Is this difference statistically significant? Support your answer with an appropriate statistical analysis.

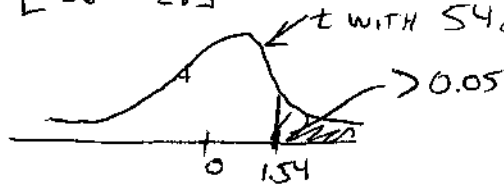
THERE ARE 54 TREATMENTS IN THIS EXPERIMENT WITH 2 REPS PER TREATMENT. THE AVERAGE FOR MALES (22.43 FEET) IS THE MEAN OF 26 TREATMENT MEANS. THE AVERAGE FOR FEMALES (20.60 FEET) IS THE MEAN OF 28 TREATMENT MEANS.

$$\hat{C} = 22.43 - 20.60 = 1.83$$

$$SE(\hat{C}) = \sqrt{\frac{37.89}{2}\left[\underbrace{\left(\tfrac{1}{26}\right)^2 + \cdots + \left(\tfrac{1}{26}\right)^2}_{26 \text{ TERMS}} + \underbrace{\left(\tfrac{-1}{28}\right)^2 + \cdots + \left(\tfrac{-1}{28}\right)^2}_{28 \text{ TERMS}}\right]}$$

$$= \sqrt{\frac{37.88}{2}\left[\frac{1}{26} + \frac{1}{28}\right]} = 1.185$$

$$t = \frac{1.83}{1.185} = 1.54$$



2-SIDED P-VALUE > 0.10

NO SIGNIFICANT DIFFERENCE.