```
/* Montgomery 6.5 */
proc import datafile="/home/u63048916/STAT571B/Homework/Homework 5/Q6-5.xlsx"
    dbms=xlsx
    out=mont6_5
    replace;
    getnames=yes;
run;

data one;
    set mont6_5;
        A=Size;
        B=Speed;
        AB=Size*Speed;
        resp=Vibration;

proc glm data=one;
class A B;
model resp=A B A*B;   /* use A*B if you want to generate an interaction plot */
means A|B;
output out=diag r=res p=pred;
run;

/* check normality */
proc univariate data=diag normal;
var res;
qqplot res / normal (mu=est sigma=est);
Run;

/* check constant variance using graph*/
title 'residual plot: res vs predicted value ';
proc sgplot data=diag;
scatter x=pred y=res;
refline 0;
run;

title 'residual plot: res vs A ';
proc sgplot data=diag;
scatter x=A y=res;
refline 0;
run;

title 'residual plot: res vs B ';
proc sgplot data=diag;
scatter x=B y=res;
refline 0;
run;

title 'residual plot: res vs AB ';
proc sgplot data=diag;
scatter x=AB y=res;
refline 0;
run;
```

6.5. A router is used to cut locating notches on a printed circuit board. The vibration level at the surface of the board as it is cut is considered to be a major source of dimensional variation in the notches. Two factors are thought to influence vibration: bit size (A) and cutting speed (B). Two bit sizes ($\frac{1}{16}$ and $\frac{1}{8}$ in.) and two speeds (40 and 90 rpm) are selected, and four boards are cut at each set of conditions shown below. The response variable is vibration measured as the resultant vector of three accelerometers (x, y, and z) on each test circuit board.

			Replicate			
A	B	Treatment Combination	I	II	III	IV
−	−	(1)	18.2	18.9	12.9	14.4
+	−	a	27.2	24.0	22.4	22.5
−	+	b	15.9	14.5	15.1	14.2
+	+	ab	41.0	43.9	36.3	39.9

(**a**) Analyze the data from this experiment.

(**b**) Construct a normal probability plot of the residuals, and plot the residuals versus the predicted vibration level. Interpret these plots.

(**c**) Draw the AB interaction plot. Interpret this plot. What levels of bit size and speed would you recommend for routine operation?

```
/* Montgomery 6.12 */
proc import datafile="/home/u63048916/STAT571B/Homework/Homework 5/Q6-12.xlsx"
    dbms=xlsx
    out=mont6_12
    replace;
    getnames=yes;
run;

data one;
    set mont6_12;
        A=Rate;
        B=Time;
        AB=Rate*Time;
        resp=Thickness;


proc glm data=one;
class A B AB;
model resp=A B AB;   /* use A*B if you want to generate an interaction plot */
estimate "A" A -1 1;
estimate "B" B -1 1;
estimate "AB" AB -1 1;
output out=diag r=res p=pred;
run;

/* check normality */
proc univariate data=diag normal;
var res;
qqplot res / normal (mu=est sigma=est);
Run;

/* check constant variance using graph*/
title 'residual plot: res vs predicted value ';
proc sgplot data=diag;
scatter x=pred y=res;
refline 0;
run;

title 'residual plot: res vs Order ';
proc sgplot data=diag;
scatter x=A y=res;
refline 0;
run;

title 'residual plot: res vs Operator ';
proc sgplot data=diag;
scatter x=B y=res;
refline 0;
run;

title 'residual plot: res vs Method ';
proc sgplot data=diag;
scatter x=AB y=res;
refline 0;
run;


proc reg data=one;
model resp=A B AB;
run;

/* check outliers */
data outlier;
set diag;
stdres=res/0.31904004;
run;

proc print data=outlier;
run;
```

6.12. An article in the *AT&T Technical Journal* (March/April 1986, Vol. 65, pp. 39–50) describes the application of two-level factorial designs to integrated circuit manufacturing. A basic processing step is to grow an epitaxial layer on polished silicon wafers. The wafers mounted on a susceptor are positioned inside a bell jar, and chemical vapors are introduced. The susceptor is rotated, and heat is applied until the epitaxial layer is thick enough. An experiment was run using two factors: arsenic flow rate (A) and deposition time (B). Four replicates were run, and the epitaxial layer thickness was measured (μm). The data are shown in Table P6.1.

(**a**) Estimate the factor effects.

(**b**) Conduct an analysis of variance. Which factors are important?

(**c**) Write down a regression equation that could be used to predict epitaxial layer thickness over the region of arsenic flow rate and deposition time used in this experiment.

(**d**) Analyze the residuals. Are there any residuals that should cause concern?

(**e**) Discuss how you might deal with the potential outlier found in part (d).

■ **TABLE P6.1**
The 2^2 Design for Problem 6.12

		Replicate					Factor Levels	
A	*B*	I	II	III	IV		Low (−)	High (+)
−	−	14.037	16.165	13.972	13.907	*A*	55%	59%
+	−	13.880	13.860	14.032	13.914			
−	+	14.821	14.757	14.843	14.878	*B*	Short	Long
+	+	14.888	14.921	14.415	14.932		(10 min)	(15 min)