Common mistakes:

(1) **Experimental unit**: what we randomly assign treatments on
Observational unit: what we collect response variables from
They may or may not be the same
(2) **Replication**: Multiple experimental units in each treatment
(3) **Blocking**: All experimental units into several blocks with units in the same block sharing something in common, each block receives all treatments
(4) **For a study to be an experiment (experimental study),** experimental units must be assigned to different treatments by the investigator, i.e., the investigator has the power to allocate which experimental unit receives which treatment.
(5) **Treatment** can be combination of 2 or more factors. If factor A,B,C each has 2 different levels, the number of different treatments will be 2*2*2=8

1. 10 points

Experiment I:

(a) (i) experimental units are pots (or seedling)
(ii) observational units are pots (or seedling)
(iii) treatments are combinations of fertilizer amount and genotype
(iv) response variable is fresh weight of seedlings.

(b) (i) replication: utilized because for each treatment there are three pots (three experimental units),
(ii) blocking: not utilized
(iii) randomization: utilized for random assignment of fertilizer amount and genotype.

Experiment II:

(a) (i) experimental units are classes
(ii) observational units are students
(iii) treatments are usage of clickers
(iv) response variable is final exam scores.

(b) (i) replication: not utilized
(ii) blocking: not utilized
(iii) randomization: utilized for random assignment of usage of clickers to classes.

2. 5 points

Design 2.

For design 1, the experimental unit is farm and observational unit is each steer. With design 1, there is only one experimental unit for each treatment and hence no replication. It is not a good experiment at all.

For design 2, the experimental unit (& observational unit) is steer and there are five experimental units for each treatment (replication). In addition, it controls farm variation by blocking.

3. 5 points

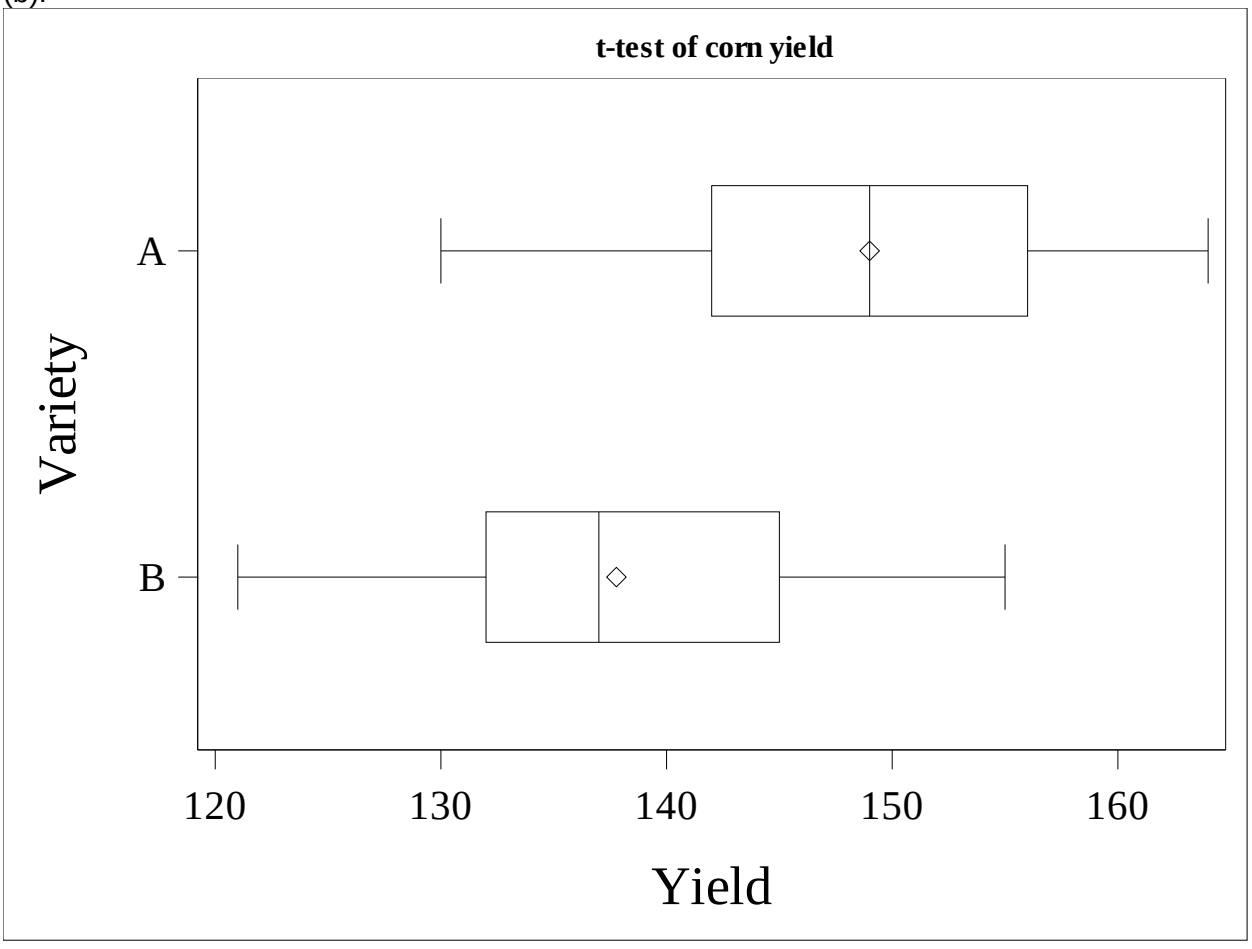
(a)
No. The treatments are not assigned by the investigator but determined by the patients.
(b)
Control of extraneous variance: No, the treatments are determined by patients thus patients receiving 2 treatments may not be homogeneous
Randomization: No, the treatments are determined by patients
Replication: Yes, multiple experimental units in each treatment

4. 15 points

See farming.sas for code used here.
(a).

Statistic	Variety A	Variety B
Q1	142	132
Q3	156	145
IQR	14	13
Median	149	137
Sample Mean	149	137.78
Sample Std. Dev.	9.22911	9.13658

(b).



(c). The median and mean of yields of Variety A are about 11.22 higher than that of Variety B, while their IQR and sample standard deviation are similar.

(d).
Null hypotheses: the mean yields of the Variety A and B are the same.
Alternative hypotheses: the mean yields of the Variety A and B are different.
Test statistics: observed mean yield difference is 11.22.
p-value: 0.0013 (depends on your permutation result)
Conclusion: under 95% confidence level we reject the null hypothesis and conclude that the mean yields of the two varieties are different at significant level of 0.05. We will be using corn of variety A.

p-Values			
Variable	**Contrast**	**Raw**	**Permutation**
Yield	A vs B	0.0008	0.0013

The latter one 0.0013 is the p-value from randomized permutation test (what we want).
0.0008 is the p-value for a 2-sample t test.

5. 10 points
a. Sample mean for Treatment 1 is (4.8 + 5.2 + 5.0)/3 = 5, sample mean for Treatment 2 is (7.7 + 8.2 + 8.1)/3 = 8. So the sample mean difference is (8 - 5) = 3 or (5 – 8) = -3.
b. (6 choose 3) = 20
c.

Treatment 1			Treatment 2			Diff
4.8	5.2	5	7.7	8.2	8.1	-3
4.8	5.2	7.7	5	8.2	8.1	-1.2
4.8	5.2	8.2	5	7.7	8.1	-0.86667
4.8	5.2	8.1	5	7.7	8.2	-0.93333
4.8	5	7.7	5.2	8.2	8.1	-1.33333
4.8	5	8.2	5.2	7.7	8.1	-1
4.8	5	8.1	5.2	7.7	8.2	-1.06667
4.8	7.7	8.2	5.2	5	8.1	0.8
4.8	7.7	8.1	5.2	5	8.2	0.733333
4.8	8.2	8.1	5.2	5	7.7	1.066667
5.2	5	7.7	4.8	8.2	8.1	-1.06667
5.2	5	8.2	4.8	7.7	8.1	-0.73333
5.2	5	8.1	4.8	7.7	8.2	-0.8
5.2	7.7	8.2	4.8	5	8.1	1.066667
5.2	7.7	8.1	4.8	5	8.2	1
5.2	8.2	8.1	4.8	5	7.7	1.333333
5	7.7	8.2	4.8	5.2	8.1	0.933333
5	7.7	8.1	4.8	5.2	8.2	0.866667
5	8.2	8.1	4.8	5.2	7.7	1.2

7.7	8.2	8.1	4.8	5.2	5	3

d. Only 2 of the 20 possible random assignments would have led to a difference between treatment means as large as 3. Thus, under the assumption of no difference in the means of the two groups, the chance of seeing a difference as large as we observed was 2/20 = 0.1.

6. 5 points

(a) $2\mu_1 + 3$, $\mu_1 + \mu_2 + \mu_3$
(b) c, 0
(c) $2\sigma^2$, $\sigma^2/2$
(d) $n\sigma^2$, σ^2/n