1. Although psychologists do not completely understand the phenomenon of dreaming, it does appear that people need to dream (or, at the very least, need REM sleep). One experiment demonstrating this fact shows that people who are deprived of REM sleep one night tend to have more REM sleep (dreams?) the following night, as if they were trying to make up for the lost REM sleep. In a typical version of this experiment, the psychologist first records the number of periods of REM sleep during a normal night's sleep. The next night, each participant is prevented from REM sleep by being awakened as soon as he or she begins to exhibit REM sleep. During the third night, the psychologist once again records the number of periods of REM sleep. Hypothetical data from this experiment are seen below. Analyze and interpret these results as completely as you can. [15 pts]

Participant	First Night	Night After Deprivation	P
1	4	7	11
2	5	5	10
3	4	8	12
4	6	7	13
5	4	9	13
6	5	7	12
7	4	7	11
8	4	6	10
Sum (*T*)	36	56	92
ΣX^2	166	402	568
SS	4	10	

H_0: $\mu_{\text{First Night}} = \mu_{\text{Night After Deprivation}}$	H_1: Not H_0	$F_{\text{Crit}}(1,7) = 5.59$

Source	*SS*	*df*	*MS*	*F*
Treatment	25	1	25	19.44
Error	14	14		
Subject	5	7		
Resid Error	9	7	1.29	
Total	39	15		

$$SS_{Total} = 568 - \frac{92^2}{16} = 568 - 529 = 39$$

$$SS_{Treatment} = \frac{36^2 + 56^2}{8} - \frac{92^2}{16} = 554 - 529 = 25$$

$$SS_{Error} = SS_{First} + SS_{AfterDep} = 4 + 10 = 14$$

$$SS_{Participant} = \frac{11^2 + 10^2 + 12^2 + 13^2 + 13^2 + 12^2 + 11^2 + 10^2}{2} - \frac{92^2}{16} = 534 - 529 = 5$$

Decision: Because $F_{\text{Obtained}} \geq F_{\text{Critical}}$, reject H_0.
Conclusion: Sleep deprivation has a significant effect on amount of REM sleep, F(1,7) = 19.44, MSE = 1.29, p < .05. After being deprived of REM sleep, people have significantly more time in REM sleep (*M* = 6.22) and before being deprived of REM sleep (*M* = 4.0). {You might want to worry that on the first night in the lab, people's sleep may have been disrupted by the novel surroundings.}

2a. Dr. Kip Werkin is an industrial/organizational psychologist who is interested in the impact of environmental factors (such as noise) on productivity. He has a group of ten workers experience each of a set of background noise levels (70 dB, 80 dB, 90 dB, and 100 dB SPL) as they work on a project that involves creating delicate instruments. (SPL = Sound Pressure Level) The dependent variable is the number of errors made in the construction of the pieces. Complete the source table and tell Dr. Werkin what he should conclude from this study. [10 pts]

ANOVA Table for SPL

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Subject	9	4.000	.444				
Category for SPL	3	13.900	4.633	22.339	<.0001	67.018	1.000
Category for SPL * Subject	27	5.600	.207				

Means Table for SPL
Effect: Category for SPL

	Count	Mean	Std. Dev.	Std. Err.
SPL 70 dB	10	.200	.422	.133
SPL 80 dB	10	.200	.422	.133
SPL 90 dB	10	1.000	.667	.211
SPL 100 dB	10	1.600	.516	.163

First of all, you would reject H_0 [$\mu_{70} = \mu_{80} = \mu_{90} = \mu_{100}$], concluding that the noise level had an impact on number of construction errors made, $F(3,27) = 22.339$, $MSE = .207$, $p < .001$. To determine which specific groups differed, you would compute Tukey's HSD:

$$HSD = q\sqrt{\frac{MS_{Error}}{n}} = 3.86\sqrt{\frac{.207}{10}} = .555$$

Thus, the 100 dB group produced significantly more errors than all other groups. The 90 dB group made more errors than the 70 dB and the 80 dB groups.

2b. If the ***same*** data were analyzed with an independent groups design, what would the source table look like? Under which conditions would a repeated measures analysis of a data set not lead to a larger F-ratio than an independent groups analysis? **If the SS_{Subj} is relatively small, then the repeated measures ANOVA will not yield a larger F.** [5 pts]

Source	df	SS	MS	F
Treatment	3	13.9	4.633	17.37
Error	36	9.6	.267	
Total	39	23.5		

3a. Before making a decision about his advertising campaign, a publisher ran an experiment to discover whether readers' responses to certain ads differed. He wanted to test responses to three kinds of ads: ads with a color picture, ads with a black-and-white picture, and ads with no picture. Each ad was inserted with other material intended to draw attention away from the material being evaluated. Participants rated the critical ad on an 11-point scale (1 = little preference for the ad, 11 = great preference for the ad). Results for the 24 participants are given below. Analyze the results as completely as you can and then interpret the results. [20 pts]

	Color Picture	Black-and-White Picture	No Picture
	3	4	10
	3	7	7
	7	5	8
	6	3	5
	8	9	9
	1	8	7
	5	7	6
	3	5	8
Sum (*T*)	36	48	60
ΣX^2	202	318	468
SS	40	30	18

H_0: $\mu_{Color} = \mu_{B+W} = \mu_{No\ Pic}$	H_1: Not H_0	$F_{Crit}(2,21) = 3.47$

Source	*SS*	*df*	*MS*	*F*
Treatment	36	2	18	4.3
Error	88	21	4.19	
Total	124	23		

$$SS_{Total} = 988 - \frac{144^2}{24} = 988 - 864 = 124$$

$$SS_{Treatment} = \frac{36^2 + 48^2 + 60^2}{8} - \frac{144^2}{24} = 900 - 864 = 36$$

$$SS_{Error} = SS_{Color} + SS_{B+W} + SS_{NoPic} = 40 + 30 + 18 = 88$$

Decision: Reject H_0, because $F_{Obtained} \geq F_{Critical}$.
Conclude: The nature of the ads had an impact on evaluations, $F(2,21) = 4.3$, $MSE = 4.19$, $p < .05$.

In order to determine which means differed, you need to compute a post hoc analysis (e.g., Tukey's HSD).

$$HSD = q\sqrt{\frac{MS_{Error}}{n}} = 3.57\sqrt{\frac{4.19}{8}} = 2.58$$

	Color	B+W	NoPic
Color	**-**		
B+W	**1.5**	**-**	
NoPic	**3.0**	**1.5**	**-**

People preferred the ads with no picture (M = 7.5) over those with color pictures (M = 4.5). Ads with black and white pictures (M = 6) didn't differ from ads with color pictures or with no pictures.

3b. [No computation is necessary to answer this part of the question.] Suppose that the *same 24 pieces of data* had been obtained from only 8 participants (in 3a) in a repeated measures analysis. How would your interpretation of the results be most likely to differ? Under which conditions would the *F*-ratio for Type of Ad be larger as a result of the new analysis? Under which conditions would the *F*-ratio be smaller as a result of the new analysis? [Examples, such as a possible source table, are not essential but might help here.] [5 pts]

Given the greater power of the repeated measures design, you'd definitely expect that the F would be larger than 4.3 in the ANOVA based on a repeated measures design/analysis. At the same time, you should be concerned that eight participants would not be an appropriate number to counterbalance the design with three levels of the factor (complete counterbalancing would require a multiple of six participants, given the six unique orders). The *F*-ratio would be larger as long as there was a substantial amount of individual difference variability. With little variability due to individual differences, the *F*-ratio for the repeated measures analysis would likely be smaller.