Regulations require that product labels on containers of food that are available for sale to the public accurately state the amount of food in these containers. Specifically, if milk containers are labeled to have 128 fluid ounces and the mean number of fluid ounces of milk in the containers is at least 128 , the milk processor is considered to be in compliance with the regulations. The filling machines can be set to the labeled amount. Variability in the filling process causes the actual contents of milk containers to be normally distributed. A random sample of 12 containers of milk was drawn from the milk processing line in a plant, and the amount of milk in each container was recorded.

(a) **(8 pts)** The sample mean and standard deviation of this sample of 12 containers of milk were 127.2 and 2.1 ounces, respectively. Is there sufficient evidence to conclude that the packing plant is not in compliance with the regulations? Provide statistical justification for your answer.

Inspectors decide to study a particular filling machine within this plant further. For this machine, the amount of milk in the containers has a mean 128.0 fluid ounces and a standard deviation of 2.0 fluid ounces.

(b) **(6 pts)** What is the probability that randomly selected container filled by this machine contains at least 125 fluid ounces?

(c) **(6 pts)** An inspector will randomly select 12 containers filled by this machine and record the amount of milk in each. What is the probability that the minimum (smallest amount of milk) recorded in the 12 containers will be at lest 125 fluid ounces? (Note: In order for the minimum to be at least 125 fluid ounces, each of the 12 containers must contain at lest 125 fluid ounces.)

During the 1950s, radioactive waste leaked from a storage area near Hanford, Washington, into Columbia River nearby. For nine counties downside in Oregon, an index exposure $X$ was calculated (based on distance from Hanford, and distance of the average citizen from the river, etc). The cancer mortality $Y$ was also calculated (deaths per 100,000 persons years, 1959-64), giving the following data (Fadeley 1965, via Anderson and Sclove, 1978):

| County | Radioactive Exposure $X$ | Cancer Mortality $Y$ |
|---|---|---|
| Clastop | 8.3 | 210 |
| Columbia | 6.4 | 180 |
| Gilliam | 3.4 | 130 |
| Hood River | 3.8 | 170 |
| Morrow | 2.6 | 130 |
| Portland | 11.6 | 210 |
| Sherman | 1.2 | 120 |
| Umatilla | 2.5 | 150 |
| Wasco | 1.6 | 140 |

From this data, summary statistics were computed:

$$\overline{X} = 4.6, \quad \overline{Y} = 160, \quad \sum_i \left(X_i - \overline{X}\right)\left(Y_i - \overline{Y}\right) = 876,$$

$$\sum_i \left(X_i - \overline{X}\right)^2 = 97.0, \quad \sum_i \left(Y_i - \overline{Y}\right)^2 = 9400.$$

(a) **(10 pts)** Calculate the regression line for predicting $Y$ from $X$.

(b) **(5 pts)** Interpret the slope in the context of this situation.

(c) **(5 pts)** Estimate the cancer mortality if $X$ were 5.0.

The principal at Crest Middle School, which enrolls only sixth-grade and seventh-grade-students, is interested in determining how much time students at that school spend on homework each night. The table below shows the mean and standard deviation of the amount of time spent on homework each night (in minutes) for a random sample of 20 sixth-grade students and a separate random sample of 20 seventh-grade students at this school

| | Mean | Standard deviation |
|---|---|---|
| Sixth-grade students | 27.3 | 10.8 |
| Seventh-grade students | 47.0 | 12.4 |

Based on dotplots of these data it is not unreasonable to assume that the times for each grade were approximately normally distributed.

(a) **(8 pts)** Estimate the difference in mean times spend on homework for all sixth- and seventh-grade students using an interval. Be sure to interpret your interval.

(b) **(4 pts)** An assistant principal reasoned that a much narrower confidence interval could be obtained if the students were paired based on their responses; for example, pairing the sixth-grade student and the seventh-grade student with the highest number of minutes spent on homework, the sixthgrade student and the seventh-grade student with the next highest number of minutes spent on homework, and so on. Is the assistant principal correct in thinking that matching students in this way and then computing a matched-pairs confidence interval for the mean difference in time spent on homework is a better procedure that the one used in part (a)? Explain why or why not.

(c) **(8 pts)** Test a hypothesis on mean equality.

Four types of cars were tested for the gas consumption per 100 km. 12, 8, 7, and 9 cars were tested of types $A, B, C$, and $D$, respectively. Average gas consumption in these tests were 9.75, 11.25, 9.00, and 11.0 liters per 100 km for the types $A, B, C$, and $D$, respectively. To test null hypothesis that all cars have equal gas consumption results were arranged in ANOVA table, but some entries in the table are missed.

| Source of Variation | DF | $SS$ | $MS$ | $F$ | F-crit (1%) |
|---|---|---|---|---|---|
| Between Groups | | | | | |
| Within Groups | | | 3.0241 | | |
| Total | | | | | |

(a) **(8 pts)** Complete the table using the information provided above.

(b) **(5 pts)** Is there any significant difference in gas consumption between 4 types of cars? (use 1% significance level).

(c) **(7 pts)** Construct a 99% confidence interval for the difference of gas consumption between cars of types $A$ and $B$.

Once upon a time there was a hypothesis about influence of a midterm on student's happinnes. As you know all methods and tools to test this hypothesis we prepared a data set. We asked 1993 students on campus about their rating score and level of happiness. Here are the data:

| Rating | Not Happy | Pretty Happy | Very Happy | Total |
|---|---|---|---|---|
| Above average | 26 | 233 | 164 | 423 |
| Average | 117 | 473 | 293 | 883 |
| Below average | 172 | 383 | 132 | 687 |
| Total | 315 | 1089 | 589 | 1993 |

(a) **(4 pts)** Based on the data in the table and without doing any significance table how would you describe the relationship between rating score and happiness.

(b) **(10 pts)** Calculate $\chi^2$ statistic and use it to test for independence using 5 % significance level. What do you conclude?

(c) **(6 pts)** Please describe stratified and clustered sampling methods.