

**UNIVERSITY OF RUHUNA – FACULTY OF ALLIED HEALTH SCIENCES****DEPARTMENT OF PHARMACY****SECOND BPHARM PART I EXAMINATION – MAY/JUNE 2026****PH 2143 BIOSTATISTICS II – SEQ****TIME: THREE HOURS****INSTRUCTIONS**

- There are **six** questions in this paper.
- Answer all questions.
- No paper should be removed from the examination hall.
- Do not use any correction fluid.
- Use illustrations where necessary.

PART A

01.

1.1. The following are the head circumferences (centimeters) at birth of 16 infants:

33.38 34.15 33.99 34.10 33.97 33.55 33.67 33.85 34.23 33.58
33.46 34.13 34.45 34.19 33.86 33.25

- 1.1.1. Construct the boxplot of the data. Based on the graph, how would you describe the shape of the distribution? **(10 marks)**
- 1.1.2. Construct the normal probability plot. Would you reject normality based on this plot? How would you describe the shape? Does it agree with your answer to part 1.1.1? **(10 marks)**
- 1.1.3. Out of the mean and median, which one would best describe the center of the distribution? Explain your reasons. **(10 marks)**
- 1.1.4. Give your estimate of the center. **(10 marks)**
- 1.1.5. How would you measure the variability in the distribution? What is your estimate? **(10 marks)**

- 1.2. A special diet mixed with a drug compound was designed to reduce low-density lipoproteins (LDL) cholesterol that was fed to a treatment group of rats. A placebo group of rats was fed the same special diet for the same period of time but without the drug compound.

Placebo	64	49	54	97	66	76	44	71	89	70
	62	46	77	86	71	72	71	55	60	64

Treatment	40	31	50	48	152	44	74	38	81	64
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- 1.2.1. Construct the side-by-side boxplots and normal probability plots for the treatment group and the placebo group. Are there any outliers? (10 marks)
- 1.2.2. If there are outliers, remove those from the worksheet and re-construct the side-by-side boxplots and normal probability plots for the treatment group and the placebo group. (10 marks)
- 1.2.3. What do the boxplots and normal probability plots of data and normality test tell about the underlying parent distributions? (10 marks)
- 1.2.4. Based on your results in part 1.2.3, complete the pooled t-test, the two-sample t-test, or the two-sample Wilcoxon rank-sum test to evaluate the drug compound. Give p-value and state your conclusion. (20 marks)

02. A consumer agency wanted to find out if the mean time taken by each of three brands of medicines to provide relief from a headache is the same. The first drug was administered to six randomly selected patients, the second to four randomly selected patients, and the third to five randomly selected patients. The following table gives the time (in minutes) taken by each patient to get relief from a headache after taking the medicine.

Drug I	Drug II	Drug III
34	15	44
38	21	39
42	19	54
55	25	58
47	30	
52		

- 2.1. State the null and alternative hypotheses to test the mean time taken to provide relief from a headache is the same for each of the three drugs. (10 marks)
- 2.2. Construct normal probability plots for each drug. Does the normality assumption seem to be satisfied? (10 marks)
- 2.3. Construct side by side boxplots. Does it appear that there is a difference among the three drugs? (10 marks)
- 2.4. Obtain the sample standard deviation for each brand of drugs. Do you think the population standard deviations are homogeneous? Explain. (10 marks)
- 2.5. Do you think that the three assumptions for the F test in one-way analysis of variance are satisfied? Explain. (10 marks)

- 2.6. Obtain the analysis of variance output for the above data. (10 marks)
- 2.7. Test the hypothesis that the mean time taken to provide relief from a headache is the same for each of the three drugs at 5% level of significance. Be sure to state your conclusions. (20 marks)
- 2.8. Determine whether a multiple comparison test is necessary. If it is, complete the test and indicate what differences exist among the three drugs. (20 marks)
03. In one stage of the development of a new drug for allergy, an experiment is conducted to study how different dosages of drug affect the duration of relief from the allergic symptoms. Ten patients are included in the experiment. The table below shows the dosage (x) in milligrams and the number of days for relief (y) from allergy for the 10 patients.

Dosage (x)	Duration for Relief (y)
3	9
3	5
4	12
5	9
6	14
6	16
7	22
8	18
8	24
9	22

- 3.1. Construct a scatter diagram. Does it appear a linear relationship between dosage and duration of relief? (10 marks)
- 3.2. Obtain the least square estimates of β_0 and β_1 for the model $y = \beta_0 + \beta_1 x + \varepsilon$. (10 marks)
- 3.3. Interpret the meaning of β_1 in this problem. (20 marks)
- 3.4. Test the hypothesis that $\beta_1 = 0$. Write down the value of test statistic and p-value. Do the results of this test indicate that a linear trend is significant? (20 marks)
- 3.5. How much of the variability in y is explained by the linear regression model? (20 marks)
- 3.6. A new trial is to be made on a single patient with the dosage 6.5 milligrams. Predict the duration of relief. (20 marks)

PART B

04.

4.1. Briefly explain the following terms in hypothesis testing.

4.1.1. Type I error

(10 marks)

4.1.2. Type II error

(10 marks)

4.2. Suppose a random sample of 170 patients having the skin disease are classified into the three age categories yielding the frequencies given in the following table.

	Age Category		
Severity	A	B	C
Moderate	15	32	18
Severe	9	49	47

4.2.1. State the null and alternative hypotheses to test whether the severity of the disease is independent of the age of the patient.

(10 marks)

4.2.2. Calculate the value of test statistic.

(20 marks)

4.2.3. Write your conclusion.

(20 marks)

4.3 Briefly explain the following designs.

4.3.1. Completely Randomized Design

(15 marks)

4.3.2. Randomized Block Design

(15 marks)

05.

5.1. If a comparative binary outcome is being considered, it will be possible to construct a 2x2 table as shown below.

Cell Counts

	Success	Failure	Total
New Treatment	n_{11}	n_{12}	n_{1+}
Control	n_{21}	n_{22}	n_{2+}
Total	n_{+1}	n_{+2}	n

Cell Probabilities

	Success	Failure
New Treatment	π_1	$1 - \pi_1$
Control	π_2	$1 - \pi_2$

5.1.1. Define the odds of success in treatment group.

(10 marks)

5.1.2. Define the odds ratio for the above 2x2 table.

(10 marks)

5.2. Answer the following questions using the data obtained from the General Social Survey.

Lung Condition by Smoking Status and City

	City A			City B			City C	
	Healthy	Not Healthy		Healthy	Not Healthy		Healthy	Not Healthy
Nonsmoker	10	6		14	12		6	12
Smoker	3	12		5	9		2	6

- 5.2.1. Write the estimated odds ratio for the marginal association estimated between smoking status and lung condition. Interpret the value of the appropriate marginal odds ratio. (20 marks)
- 5.2.2. Write the estimated odds ratios for conditional association between smoking status and lung condition on cities. (20 marks)
- 5.2.3. Is there evidence for conditional independence between smoking status and lung condition (conditional on cities)? (40 marks)

06.

- 6.1. Explain the three categories of statistical quality control (SQC). (30 marks)
- 6.2. Explain the process shifts detected by $\bar{x}$ -charts and R -charts. (30 marks)
- 6.3. A quality control inspector at the Beautiful Shampoo Company selected three samples, each containing four observations, to examine the volume of shampoo bottles filled. The recorded data are given below.

Sample Number	Shampoo Bottle Volume in milliliters			
	Observation 1	Observation 2	Observation 3	Observation 4
1	177.3	185.4	176.1	183.2
2	178.2	181.8	178.1	186.3
3	179.4	178.6	184.4	180.0

Develop three-sigma control limits for

6.3.1. the $\bar{x}$ -chart and

6.3.2. the R -chart

for this process.

(40 marks)