UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF PHYSICS

MAIN EXAMINATION: 2019/2020 (November)

TITLE OF PAPER: Research Methods for Physics

COURSE NUMBER: PHY351

TIME ALLOWED: TWO HOURS

INSTRUCTIONS:

- ANSWER QUESTION ONE AND ANY THREE OUT OF THE FOUR REMAINING QUESTIONS.
- POINTS FOR DIFFERENT SECTIONS ARE SHOWN IN THE RIGHT-HAND MARGIN.

THIS PAPER HAS 3 PAGES, INCLUDING THIS PAGE.

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Question 1: Compulsory Question

(a) State whether each of the following statements is true or false. (14)

i. The question, 'Why are leaves green?', is a *testable* question.

ii. *Test a hypothesis: Hypothesis-driven research*, is a research method also known as the Scientific Method.

iii. The hypothesis '*Users of Macs and PCs like their computers equally well*' is a *null hypothesis.*

iv. Increasing the number of measurements in an experiment reduces the *standard error of the mean.*

v. Given a collection of numbers $x_1, ..., x_N$, then the average of these numbers lies somewhere in the middle.

vi. For a given probability distribution $P(X)$, we have $\int P(X)dX = 0$.

vii. For a given set of data, $\{(x_1, y_1), ..., (x_N, y_N)\}$, there is a unique polynomial of order $N-1$ that passes through all of the points.

(b) Briefly describe confidence intervals and using an example discuss two possible interpretations of a confidence interval. (10)

(c) In hypothesis testing using a t-test, there are two types of error that one can make, a false positive and a false negative. With the aid of a simple table describe how the two errors arise. (6)

(d) Briefly describe linear regression. (Include relevant equations and possibly diagrams.) (10)

Question 2: One of Four Optional Questions

The formulas for the sample mean and sample variance are $\bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i$ and $s^2 = \frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2$, respectively

(a) Taking the square of the term under the summation in the variance is just one way of describing the spread of data. Discuss what problem arises if the term is not squared and give two alternative solutions to that problem. (4)

(b) The standard deviation is defined to be the square root of the variance. Explain why it is conventional to take the square root using the following set of measurements of pH to illustrate your logic: pH measurements: 7.34, 7.48, 7.12, 7.33, 7.28, 7.41, 7.22, 7.37, 7.30, 7.29. (6)

(c) Describe how you would obtain values such as the mean, variance, standard error and the p-value of the above data if you had access to either Microsoft excel or open excel or any other analysis software. (10)

Question 3: Two of Four Optional Questions

(a) Using a population estimate and other relevant assumptions, estimate the amount of rice (in kilograms) consumed in the Kingdom of Eswatini in a year. Describe how this estimate would change if you had to obtain an estimate of the amount of meali-meal consumed in the Kingdom. (10)

(b) Use dimensional analysis to show that the formula for the frequency f for a guitar string is given by (10)

$$f = C\sqrt{\frac{T}{ML}}.$$

Where C is a dimensionless constant, T is the tension on the string, M is the mass of string and L is the length of the string.

Question 4: Three of Four Optional Questions

Obtain an order of magnitude estimate for each of the problems. Note that you have to state all your assumptions and indicate how they affect the estimate.

(a) Estimate the number of privately owned cars in Mbabane. (Exclude state and company cars.) (5)

(b) Use the result from (a) to estimate the amount of fuel (petrol or diesel) consumed by privately owned cars in Mbabane in a year. (5)

(c) Estimate how high a human can jump on the moon. Note: The moon's gravitational field is 1/6 that of Earth. (5)

(d) Describe one possible way you can estimate the number of homes in the Lubombo region. (5)

Question 5: Four of Four Optional Questions

(a) Briefly describe the type of information contained in an abstract. (4)

(b) Briefly describe the type of information contained in an introduction of a scientific article. (4)

(c) Briefly describe the type of information contained in the conclusions of a scientific article. (4)

(d) Briefly describe four things to avoid when preparing a scientific presentation. (8)