Subject: Research Methodology (PH4203)
End-Semester Examination

Date 01.05.2019, 10 AM – 12.30 PM
No. of Students: 84

Answer any 5 questions

1. Answer any one of the following three options

   (a) If you are in the DPS or DMS, imagine yourself as Schrödinger and suppose you are writing the paper introducing the Schrödinger equation. Write the abstract of the paper.

   (b) If you are in the DBS or DCS, imagine yourself in the position of Watson and Crick, and suppose you are writing the paper describing the structure of the DNA. Write the abstract of the paper.

   (c) If you are in the DES, imagine yourself as Alfred Wegener, and suppose you are writing the first paper introducing the concept of plate tectonics in 1912. Write the abstract of the paper.

   You have to assume the state of knowledge as existed at the time of writing the paper, but have to use modern convention and stylistics in writing the abstract.   (10)

2. (a) Suppose two scientists have proposed two different vaccines (call them V_1 and V_2) of viral fever and you want to test if these are really effective. You gather a number of people (proper sample of all ages and sex). You apply V_1 on 120 people, V_2 on 140 people, and a placebo on 120 people. After a year you take a survey and find that, out of the people who got V_1, 20 got sick of viral fever; out of those who got V_2, 30 got sick; and out of the people who got placebo, 30 got sick. Using a χ^2 test with significance level 10% what conclusion can you reach regarding the afficacy of the vaccines?   (6)

df	$\chi^2_{.995}$	$\chi^2_{.990}$	$\chi^2_{.975}$	$\chi^2_{.950}$	$\chi^2_{.900}$	$\chi^2_{.100}$	$\chi^2_{.050}$	$\chi^2_{.025}$	$\chi^2_{.010}$	$\chi^2_{.005}$
1	0.000	0.000	0.001	0.004	0.016	2.706	3.841	5.024	6.635	7.879
2	0.010	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210	10.597
3	0.072	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.345	12.838
4	0.207	0.297	0.484	0.711	1.064	7.779	9.488	11.143	13.277	14.860
5	0.412	0.554	0.831	1.145	1.610	9.236	11.070	12.833	15.086	16.750

Table 1: The χ^2-table, showing the area to the right of the critical value in the χ^2 distribution for different degrees of freedom.

   (b) What kinds of actions are considered to be research misconduct? Explain each one briefly.   (4)

1

3. (a) Suppose there is a population of tall and short pea plants in an experimental plot. You have sampled 500 plants and have found that 330 of them are tall. With what level of confidence can you state that the actual population proportion of tall plants lies in the range between 0.65 and 0.67? (4)

(b) Discuss the effect of positivism on the history of science. Can this line of philosophy provide the guiding light for science today? Explain briefly. (6)

4. (a) Suppose you are conducting an experiment to investigate the temperature dependence of the resistance of a wire made of an alloy. You assume that the textbook relation $R = R_0(1 + \alpha T)$ holds, where R_0 is the resistance at $0°C$, α is the temperature coefficient of resistance, and R is the reistance at temperature T. The data obtained are as follows:

T (°C)	10	20	30	40	50	60	70	80
R (Ω)	12.3	12.9	13.6	13.8	14.5	15.1	15.2	15.9

Neglect the uncertainty in the measurement of temperature.

Using the method of least squares, calculate the best values of R_0 and α. State the final results in a scientifically meaningful way [1]. (6)

(b) Suppose you have used the measurements on a simple pendulum to determine the value of acceleration due to gravity, using the relation

$$T = 2\pi\sqrt{l/g}$$

The length of the chord was measured to be 0.381 m and the least count of the scale was 2 mm. The period of oscillation was measured 25 times and the mean and the standard deviation were found to be 1.24 sec and 0.1 sec respectively. How would you specify the measured value of g? (4)

5. (a) Newton's theory failed to explain the precession of the perihelion of Mercury. Can Newton's theory still be said to be 'true'? Explain your reasoning. (4)

(b) Are the following reasonings logically valid? Explain your answers.

i. Some particles have half-integer spin
No particle with half-integer spin is boson
∴ Some bosons are not particles

ii. All whales are mammals
Some mammals are carnivores
∴ Some whales are carnivores

iii. All shiny solids are metals
Sulphur is not a shiny solid
∴ Sulphur is not a metal

---

[1] In case you have forgotten the formulae, here they are: $m = \frac{N\sum(x_i y_i) - \sum x_i \sum y_i}{N\sum x_i^2 - (\sum x_i)^2}$,

$b = \frac{\sum x_i^2 \sum y_i - \sum x_i \sum(x_i y_i)}{N\sum x_i^2 - (\sum x_i)^2}$, $s_m = s_{\delta y} \times \sqrt{\frac{N}{N\sum x_i^2 - (\sum x_i)^2}}$, $s_b = s_{\delta y} \times \sqrt{\frac{\sum x_i^2}{N\sum x_i^2 - (\sum x_i)^2}}$

Clue: Don't decide on the basis of your prior knowledge. Check if the conclusion logically follow from the given premises. (6)

6. (a) The pressure inside a soap bubble is dependent on the surface tension of the material and the radius of the bubble. Use dimensional analysis to find the nature of dependence. (4)

   (b) The following statements are given:
   - If the concentration of chlorofluorocarbon (CFC) in the air exceeds a threshold, there will be hole in the ozone layer
   - If there is hole in the ozone layer, a larger amount of ultraviolet radiation will reach Earth's surface
   - Ultraviolet radiation causes cancer

   What conclusions can you draw using valid logic if the following premises are also given (consider each one separately)

   i. There is increase in CFC in the air beyond the threshold.
   ii. Statistical survey showed that incidence of cancer has increased.
   iii. Statistical survey showed that incidence of cancer has not increased.
   iv. Measurement showed that the amount of UV radiation reaching Earth's surface has not increased. (1.5 × 4)

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
0.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
0.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
0.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
0.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
0.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
0.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
0.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
0.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
0.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817

The z-table for positive values of z