Graduate Course – Term 1, Sept-Dec 2018
30.502: Research Methods

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN
Established in collaboration with MIT

Assessed Problem Set 3

Due: Wed, 31st Oct, 23:59PM
Delivery method: E-dimension
Format: Portable Document Format (PDF)

For all the python based questions in this problem set, please copy and past the code that you used for each function/operation and the result of the calculation.

Problem 1: Propagation of Error

Snell's law relates the angle of refraction θ_2 of a light ray in a medium of refractive index n_2 to the angle of incidence θ_1 of a ray travelling in a medium of index n_1 through the equation $n_2 \sin\theta_2 = n_1 \sin\theta_1$.

i Find n_2 and its uncertainty from the following measurements: $\theta_1 = 22.02 \pm 0.02°$, $\theta_2 = 14.45 \pm 0.02°$, and $n_1 = 1.0000$

ii Draw a block flow diagram to show how you would compute the mean and uncertainty in n_2 using a Monte Carlo algroithm

iii Compute the mean and standard deviation using your Monte Carlo algorithm. Plot a histogram to show the distribution of n_2 for N=10, 100, and 10^4 computations. Comment on the result.

Problem 2: Goodness of fit

Table 1 gives the age distribution of part-time college students as determined five years ago.

Age	18-24	25-34	35-44	45-54	55 and over
Percent	25%	35%	25%	10%	5%

Table 1: Age distribution of part time college students 5 years ago

1500 part-time students were recently surveyed across the Singapore. 352 were in the age group 18-24, 501 were in the age group 25-34, 371 were in the age group 35-44, 126 were in the age group 45-54, and the remainder were in the age group 55 or over.
Here we aim to understand whether the proportions from 5 years ago are representative of today's college student proportions?

i Write the null hypothesis, H_0, and alternative, H_a, hypothesise

ii Compute the χ^2 test statistic (if you use python, please include your code, if you do it manually by hand, please copy out a table showing your calculations)

iii Is there a statistically signifficant difference in the proportions at the $\alpha = 0.01$ signifficance level?

Problem 3: Confidence

In a random sample of 85 bearings, 10 have a surface roughness that is larger than specifications allow.

i Estimate of the proportion, $\hat{p}$, of bearings that exceed the roughness specification.

ii Calculate the 95% two-sided confidence interval for the proportion of bearings that are rougher than specification.

iii How large should the sample be if we want to be *at least* 95% confident that our estimate $\hat{p}$ is within 0.05 of the true proportion, p?