# Tutorial 1

PHC 501/643 COMPUTER PROGRAMMING SPRING 2024

1. A rocket starts with a velocity $u = 4 \times 10^5$ m/s and moves in a straight line with a net acceleration of $a = 10$ m/s$^2$. Write a program to display the velocity ($v = u + at$) of the rocket at the following times (in minutes) $t = 0, 5, 10, ..., 25$.

2. Write a program which reads two matrices as lists and return the sum and product of the two matrices using the formulae
$$(A+B)_{i,j} = a_{i,j} + b_{i,j},$$
$$(AB)_{i,j} = \sum_{k=1}^{m} a_{i,k} + b_{k,j}.$$

3. Write a program which reads $x_1, f(x_1), x_2, f(x_2)$ and $x$, and returns the value of $f(x)$. Assume that the three points $(x, f(x))$, $(x_2, f(x_2))$ and $(x, f(x))$ lie in the same line.

4. Write a program which reads $j_1$ and $j_2$ and returns the output as an array of values from $|j_1 - j_2|$ to $j_1 + j_2$ in steps of unity.

5. Write a function script for
$$\cos x = \lim_{N\to\infty} \sum_{n=0}^{N} (-1)^n \frac{x^{2n}}{(2n)!}.$$
$$\sin x = \lim_{N\to\infty} \sum_{n=1}^{N} (-1)^{n+1} \frac{x^{2n-1}}{(2n-1)!}.$$
Compare the approximations to the values calculated directly from `numpy.sin` for $x = 0, 1/4, 1/2$ and $3/4$. Choose $N = 5, 10$, and 20.

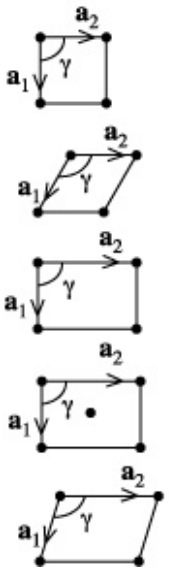
6. Show that, within the accuracy permitted,
$$\lim_{N\to\infty} \sum_{n=1}^{N} \frac{(-1)^n}{n} = -\ln 2, \quad \text{and} \quad \lim_{N\to\infty} \sum_{n=1}^{N} \frac{1}{n(n+1)} = 2$$

7. Show that $\sum_{i=1}^{n} i = \frac{1}{2} n(n+1)$.

8. The number of modes of transmission in a fiber optic cable is given by
$$N_m = 0.5 \left( \frac{\pi D \times NA}{\lambda} \right),$$
where $D$ is the core diameter of the fiber optic cable, $\lambda$ is the wavelength of the light used and the numerical aperture $(NA)$ is given by $NA = \sqrt{n_1^2 - n_2^2}$. Write a function script which takes the input values ($n_1$ , $n_2$, $D$ and $\lambda$) and gives out the number of modes possible in the given fiber.

9. Write a program to find the angles in an arbitrary triangle, given the lengths of the three sides. If you use the law of cosines you will find it helpful to know that the built-in function `numpy.acos(x)` returns the angle, in radians, whose cosine is `x`.

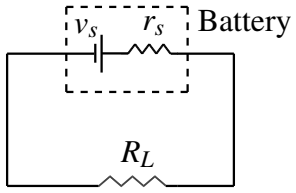
10. Based on the edge lengths ($a_1$, $a_2$) and the angle between the edges ($\gamma$), the 2D lattices can be classified into five categories as given in the figure. Write a function script which reads the values of $a_1$, $a_2$ and $\gamma$ and returns the type of the lattice.




| | | |
|---|---|---|
| **square** | $a_1 = a_2$ | $\gamma = 90°$ |
| **hexagonal** | $a_1 = a_2$ | $\gamma = 120°$ |
| **rectangular** | $a_1 \neq a_2$ | $\gamma = 90°$ |
| **centered rectangular** | $a_1 \neq a_2$ | $\gamma = 90°$ |
| **oblique** | $a_1 \neq a_2$ | $\gamma \neq 90°, 120°$ |

11. An electrical circuit that includes a voltage source $v_s$ with an internal resistance $r_s$, and a load resistance $R_L$ is shown in the figure. The power $P$ dissipated in the load is given by

$$P = \frac{v_s^2 R_L}{(R_L + r_s)^2}.$$




Write a function script which takes in the values $v_s$, $r_s$, and $R_L$ and returns the power dissipated. Then write a minimal script which calls the above function script and tabulates the power $P$ as a function of $R_L$, for $1 \leq R_L \leq 10\ \Omega$, given that $v_s = 12$ V and $r_s = 2.5\ \Omega$.

12. Write a function which reads a one dimensional array and the number of elements, and returns the following quantities: (i) Maximum (ii) Minimum (iii) average (iv) standard deviation median (vi) sum of all the numbers and vii) product of all the numbers.

13. Your body mass index (BMI) is given by your weight (in kilos) divided by your height (in metres) squared. Write a program to read the weight and height and print out the BMI for each person. Grades of obesity according to Garrow as follows:

    (a) Grade 0 (desirable) 20–24.9

    (b) Grade 1 (overweight) 25–29.9

    (c) Grade 2 (obese) 30–40

    (d) Grad 3 (morbidly obese) $> 40$

14. The formula to calculate the period of a pendulum is $T = 2\pi\sqrt{LENGTH/9.81}$. Write a program that uses a `for` loop to make the length go from 1 to 10 metres in 1-metre increments. Produce a table with two columns, the first of lengths and the second of periods.