

MATH 440A/540A Parallel Scientific Computing

Homework – Exercise Sheet 1

(Throughout, replace **xxxx** with F90+ or C or C++. If you are not yet comfortable with any one of these languages, replace **xxxx** with Matlab or Python.)

1. Write a **xxxx** program that calculates an hourly employee's weekly pay. The program should ask the user for the person's pay rate and the number of hours worked during the week. It should then calculate the total pay from the formula
$$\text{Total Pay} = \text{Hourly Pay Rate} \times \text{Hours Worked}.$$
Finally, it should display the total weekly pay. Check your program by computing the weekly pay for a person earning the minimum Colorado State wage per hour, if the person works for 50 hours a week.
2. In Einstein's Theory of Relativity, the rest mass of matter is related to an equivalent energy by the equation $E = mc^2$, where E is the energy in joules, m is mass in kilograms, and c is the speed of light in meters per second ($c = 299,792,458\text{m/s}$). Suppose that a $yyy\text{-MW}$ (= yyy million joules per second) nuclear power generating station supplied full power to the electrical grid for a year and that the generating station is 100% efficient in producing electrical energy. Write a **xxxx** program that calculates the amount of mass consumed in the course of the year for a user specified output power yyy . Check your code with some useful yyy values of your choice. (The initial output of the first commercial nuclear power station, in 1954, was 50-MW.)
3. If P_1 is some reference power level and P_2 is the power level being measured, then the ratio of the two power measurements in decibels (dB) is given by $r_{\text{dB}} = 10 \log_{10} \frac{P_2}{P_1}$. Extend the code in Q.2, to compute the r_{dB} with reference power level level being the initial output of the first commercial nuclear power station and $P_2 = \text{xxx}$. Further generalize the code to compute $r_a = a \log_a \frac{P_2}{P_1}$, for an arbitrary logarithmic base a . Check your code with various input choices of a .
4. Suppose that you deposit a sum of money P in an interest-bearing account at a local bank. If the bank pays you an interest on the money at the rate of i percent per year and compounds the interest m times a year, the amount of money that you will have in the bank after n years is given by the equation

$$F = P \left(1 + \frac{\text{APR}}{100m} \right)^{mn},$$

where F is the future value of the account and APR is the annual percentage rate on the account. The quantity $\frac{\text{APR}}{100m}$ is the fraction of interest earned in one compounding period (the extra factor of 100 in the denominator converts the rate from percentages to fractional amounts).

Write a **xxxx** program that will read an initial amount of money P , an annual interest rate APR, the number of times m that the interest is compounded in a year, and the number of years n that the money is left in the account. The code should calculate the future value F of this account.

Run an executable version of this code to calculate the future value of the bank account if \$1000 is deposited in an account with an APR of 5% for a period of one year, and the interest is compounded (a) annually, (b) semiannually, or (c) monthly. How much difference does the rate of compounding make on the amount in the account.

5. The radial acceleration required for an object to move in a circular path is given by $a = v^2/r$, where a is the centripetal acceleration of the object in m/s^2 , v is the tangential velocity of the object in m/s , and r is the turning radius in meters. Suppose that the object is an aircraft that is moving at 80% of the speed of sound (that is, at *Mach* 0.80, where *Mach* 1 = 340m/s) and the centripetal acceleration is 2.5g, where $1g = 9.81m/s^2$.

Write a **xxxx** program to compute the turning radius of the aircraft. The program should be written in such a way that the dynamic turning radius of the aircraft can be computed with minimal effort as the speed of the aircraft increases to, say *Mach* 1.5, and that maximum acceleration that the pilot of the aircraft can stand is 7g. What is the minimum possible turning radius in the latter case?

6. The escape velocity, v_∞ (in m/s), from the surface of a planet (ignoring effects of atmosphere) is given by $v_\infty = \sqrt{2GM/R}$, where G is the gravitational constant (with approximate value $6.674 \times 10^{-11} m^3 kg^{-1} s^{-2}$), M is the mass of the planet in kilograms, and R is the radius of the planet in meters.

Write a **xxxx** program to calculate the escape velocity as a function of mass and radius and use the code to calculate the escape velocity of various bodies. In particular, compare the output from the code with your knowledge of the escape velocity of the Earth and other bodies.

You may use the following input data:

- Earth : $M = 6.0 \times 10^{24} kg$, $R = 6.4 \times 10^6 m$
- Moon : $M = 7.4 \times 10^{22} kg$, $R = 1.7 \times 10^6 m$
- Ceres : $M = 7.4 \times 10^{22} kg$, $R = 1.7 \times 10^5 m$
- Jupiter : $M = 1.9 \times 10^{27} kg$, $R = 7.1 \times 10^7 m$

7. Write a **xxxx** program to determine the kinds of integers supported by various compilers and machines for integer and real data types. Test your code on the Alamode Lab machines and on any other accessible computing environment.
8. Write a **xxxx** program compute the complex exponential defined the Euler equation $e^{i\theta} = \cos(\theta) + i \sin(\theta)$, for any value of θ . Also evaluate $e^{i\theta}$ using the intrinsic complex exponential function **CEXP**. Compare the answers you get by the two methods for the cases $\theta = 0, \pi/2, \pi$.
9. Write a **xxxx** program with input data being a complex number and the output values are the amplitude and phase of the complex number. Test your code with several input values of your choice.