MATH 440A/540A Parallel Scientific Computing
Homework – Exercise Sheet 2

(Throughout, replace `xxxx` with F90+ or C or C++.)

1. The cost of sending a package by an express delivery service is \$12.00 for the first two pounds, and \$4.00 for each pound or fraction thereof over two pounds. If the package weighs more than 70 pounds, a \$10.00 excess weight surcharge is added to teh cost. No package over 100 pounds will be accepted. Write a program in `xxxx` that accepts the weight of a package in pounds and computes the cost of mailing the package if accepted or an appropriate error message if cannot be accepted.

2. Suppose that a student has the option of enrolling for a single elective during a term. The student must select a course from a limit list of options: MATH_ELEC, PHYS_ELEC, CHEM_ELEC ENGG_ELEC. Construct a fragment of `xxxx` code that will prompt the student for a choice, read in the choice, and use the answer as the case expression for a `SELECT CASE` construct. Be sure to include a default case to handle invalid inputs.

3. Modify your codes for problems in Exercise Sheet 1 to trap any invalid input data.

4. When a ray of light passes from a region (Region 1) with an index of refraction n_1 into a region (Region 2) with a different index of refraction n_2, the light ray is bent. The angle at which the light is bent is given by *Snell's Law*:

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

   where θ_1 is the angle of incidence of the light in Region 1 and θ_2 is the angle of incidence of the light in Region 2. Write a formula to compute θ_2 as a function of θ_1, n_1, n_2.

   Write a `xxxx` program to calculate the angle of incidence (in degrees) of a light ray in Region 2 given the angle of incident θ_1 in Region 1 and the indices of refraction n_1 and n_2. Note that if $n_1 > n_2$ then for some angles θ_1 with $(n_1/n_2)\sin\theta_1 > 1$ due to the restriction of domain of $\sin^{-1}$, no real solution exists to compute θ_2. (That is, all light is reflected back to Region 1 and no light passes into Region 2.) Your program must be able to recognize and properly handle this condition and also convert input angle in degrees to radians.

   Test your program by running the code for the following two cases:
   (i) $n_1 = 1.0, n_2 = 1.7, \theta_1 = 45^o$ and (ii) $n_1 = 1.7, n_2 = 1.0, \theta_1 = 45^o$

5. The current flowing through a semiconductor diode is given by the equation

$$i_D = I_D\left[\exp(q\nu_D/kT) - 1\right],$$

   where ν_D is the voltage across the diode (in volts); i_D is the current flow through the diode (in amperes); I_D is the leakage current of the diode (in amperes); q is the charge on an electron, 1.602×10^{-19} coulombs; k is the Boltzmann constant, 1.38×10^{-23} joule/kelvin; T is the temperature in kelvins.

   Suppose that the leakage current I_D of the diode is 2.0 μA. Write a `xxxx` program to calculate the current flowing through this diode for all voltages from $-1.0\ V$ to $0.6\ V$, in $0.1\ V$ steps. Repeat this process for the following temperatures: $75^oF, 100^oF, 125^oF$. (Note: $T(in\ kelvins) = \left[\frac{5}{9}T(in\ ^oF) - 32^o\right] + 273.15$.)