Activity 1: Radioactive decay

Radioactive materials decay at a rate proportional to the amount present. Radioactive materials, and some other substances, decompose according to a formula for exponential decay. That is, the amount of radioactive material N present at time t is given by:

$$N = N_0 e^{-\lambda t}$$

in which

$$\lambda = \frac{ln(2)}{T}$$

where

$$\begin{aligned} N &= \text{amount of material at time } t\text{, any convenient units} \\ N_0 &= \text{the initial amount of material, same units as } N \\ \lambda &= \text{decay constant} \\ t &= \text{time, any convenient units} \\ T &= \text{half-life, same units as } t \end{aligned}$$

The *half-life* is the time required for half the material to decay.

TASK: A radioactive isotope has a half-life of 16 days. You wish to have 30 grams at the end of 30 days. Write a Fortran program to determine how much of the radioisotope you should start with.

Inputs include T, N, and t. The program should calculate λ and N_o, outputting the latter.

Solving the equation for N_o gives:

$$N_0 = \frac{N}{e^{-\lambda t}} = N e^{\lambda t}$$

Substituting the known values: T=16, N=30, and t=30 gives a result of 110.04 grams.

SKILLS: mathematical expressions, basic Fortran structure

Activity 2: Sun kink

Sun kink refers to a condition that can occur on hot days in rail tracks. The phenomenon is caused by thermal *buckling*. It often occurs in continuous welded rail (CWR) which is laid in segments in excess of 300m. Since expansion of CWR-track is constrained, a temperature increase will result in compressive stresses which lead to track buckling. The photograph[1] shows railway tracks distorted due to thermal expansion.

If a segment of steel railroad track has a length of 300.0m when its temperature is 15.0°C, what is the length when the temperature of the rail is 60.0°C?

If the length of a railway track is L and the change in temperature is represented by a differential amount ΔT, then the differential change in the length of the rail is given by:

$$\Delta L = \alpha L \Delta T$$

where α is the *coefficient of linear expansion*. In the case of steel, α=11e-6 °C.

Substituting in gives:

$$\Delta L = (11.0 \times 10^{-6}) \times (300.0m) \times (45.0) = 0.1485m$$

TASK: Write a Fortran program to perform the calculation, outputting the new size of the rail.

SKILLS: mathematical expressions, basic Fortran structure

[1] Photo credit: kstrebor FLICKR

Activity 3: Wave breaking

A *breaking wave* is one whose base can no longer support its top, causing it to collapse. The form of breaking waves on beaches is a continuum, but for convenience three major types can be identified: *spilling*, *plunging*, and *surging* [2].

These may be classified quantitatively by reference to the *wave period*, T (seconds), the *wave height* at breaking, H_b (cm), and the *beach slope*, m. These three variables are combined into a single (inshore) parameter, B:

$$B = \frac{H_b}{gmT^2}$$

g is gravitational acceleration (981 cm sec^{-2}). If $B < 0.003$, the breakers are surging; $B > 0.068$ they are spilling, and between these values plunging breakers are observed.

TASK: Write a Fortran program to perform the calculation. Below are some values to test the program out with.

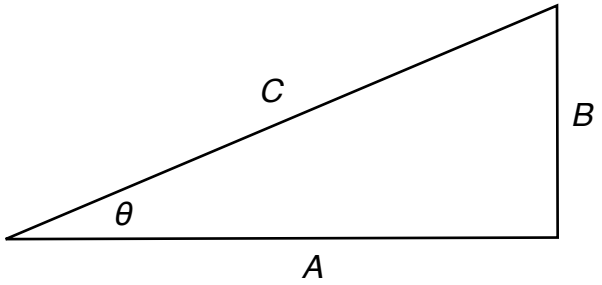
slope	*wave height*	*period*	*breaker type*
0.05	7.2	1.0	spilling
0.05	11.3	4.0	plunging
0.1	5.7	8.0	surging
0.2	6.2	1.0	plunging

SKILLS: mathematical expressions, basic Fortran structure, decision statements, I/O

[2] Galvin, C.J., Breaker type classification on three laboratory beaches. J. of Geophysical Res. 73 (12), 3651–3659, (1968).

Activity 4: Is anything wrong?

The following program calculates the lengths of two sides of a triangle (*A, B*), given the hypotenuse *C*, and angle θ.



TASK: Will the program run? Will it produce the correct result? (Try it with *C*=5, θ=30) Why or why not?

```
program triangle

real :: a, b, c, theta

write (*,*) 'Enter the length of the hypotenuse C: '
read (*,*) c
write (*,*) 'Enter the angle theta in degrees: '
read (*,*) theta

a = c * cos(theta)
b = c * sin(theta)

write (*,*) 'The length of the adjacent side is ', a
write (*,*) 'The length of the opposite side is ', b

end program triangle
```

SKILLS: reading and analysis of basic Fortran program structure