ACO Programming

```python
# Problem : Max y = x_1^2 + x_2^2 + x_3^3 + x_4^4 where x in [1,30]
# Solution: x_1 = x_2 = x_3 = x_4 = 30

# 參數
rou = 0.8                # 費洛蒙揮發係數
Q = 1                    # 費洛蒙總量

NGEN = 100               # 迴圈數
popsize = 100            # 螞蟻數

low = [1, 1, 1, 1]       # 各變數x下界
up = [30, 30, 30, 30]    # 各變數x上界

#np.random.seed(0)           # 若要每次跑得都不一樣的結果，就把這行註解掉

class ACO:
    def __init__(self, parameters):
        ...

    def fitness(self, ind_var):
        ...

    def update_operator(self, gen, t, t_max):
        ...

    def main(self):
        ...

        for gen in range(1, self.NGEN + 1):
            # 更新 費洛蒙
            ...

        # 印出結果和畫圖
        ...

parameters = [NGEN, popsize, low, up]
aco = ACO(parameters)    # 以參數 parameters 來建立一個 class ACO 的物件，叫aco
aco.main()               # 呼叫 aco 的 main 方法
```

設定參數

ACO類別

初始化

算適應度函數

更新費洛蒙

主程式

Exercise

- Benchmark functions:

Test functions	Feasible spaces	n	$f_{\min}$
$f_1(\boldsymbol{x}) = \sum_{i=1}^{n} \left(-x_i \sin\left(\sqrt{\lvert x_i \rvert}\right)\right)$	$[-500, 500]^n$	30	$-418.983n$
$f_2(\boldsymbol{x}) = \sum_{i=1}^{n} (x_i^2 - 10\cos(2\pi x_i) + 10)$	$[-5.12, 5.12]^n$	30	0
$f_3(\boldsymbol{x}) = -20\exp\left(-0.2\sqrt{\frac{1}{n}\sum_{i=1}^{n} x_i^2}\right) - \exp\left(\frac{1}{n}\sum_{i=1}^{n}\cos(2\pi x_i)\right)$ $+20 + \exp(1)$	$[-32, 32]^n$	30	0
$f_4(\boldsymbol{x}) = \frac{1}{4000}\sum_{i=1}^{n} x_i^2 - \prod_{i=1}^{n}\cos\left(\frac{x_i}{\sqrt{i}}\right) + 1$	$[-600, 600]^n$	30	0
$f_5(\boldsymbol{x}) = \frac{\pi}{n}\left\{10\sin^2(\pi y_1) + \sum_{i=1}^{n-1}(y_i - 1)^2\left[1 + 10\sin^2(\pi y_{i+1})\right] + (y_n - 1)^2\right\} + \sum_{i=1}^{n} u(x_i, 10, 100, 4)$, where $y_i = 1 + \frac{1}{4}(x_i + 1)$ and $u(x_i, a, k, m) = \begin{cases} k(x_i - a)^m, & x_i > a \\ 0, & -a \le x_i \le a \\ k(-x_i - a)^m, & x_i < -a \end{cases}$	$[-50, 50]^n$	30	0
$f_6 = \sum_{i=1}^{n}\left[\sum_{j=1}^{n}(\chi_{ij}\sin\omega_j + \psi_{ij}\cos\omega_j) - \sum_{j=1}^{n}(\chi_{ij}\sin x_j + \psi_{ij}\cos x_j)\right]^2$, where χ_{ij} and ψ_{ij} are random intergers in [-100,100], and ω_j is a random number in $[-\pi, \pi]$	$[-\pi, \pi]^n$	100	0
$f_7(\boldsymbol{x}) = \sum_{i=1}^{n-1}\left[100\left(x_i^2 - x_{i+1}\right)^2 + (x_i - 1)^2\right]$	$[-5, 10]^n$	30	0
$f_8(\boldsymbol{x}) = \sum_{i=1}^{n} x_i^2$	$[-100, 100]^n$	30	0
$f_9(\boldsymbol{x}) = \sum_{i=1}^{n} x_i^4 + \text{random}\,[0, 1)$	$[-1.28, 1.28]^n$	30	0
$f_{10}(\boldsymbol{x}) = \sum_{i=1}^{n} \lvert x_i \rvert + \prod_{i=1}^{n} \lvert x_i \rvert$	$[-10, 10]^n$	30	0
$f_{11}(\boldsymbol{x}) = \sum_{i=1}^{n}\left(\sum_{j=1}^{i} x_j\right)^2$	$[-100, 100]^n$	30	0
$f_{12}(\boldsymbol{x}) = \max\{\lvert x_i \rvert, \quad i = 1, 2, \ldots, n\}$	$[-100, 100]^n$	30	0

Exercise (cont.)

- Use the ACO sample code “ACO.py” to
  find the optimal solutions of the following three functions:

Test functions	Feasible spaces	n	$f_{\min}$
$f_1(\boldsymbol{x}) = \sum_{i=1}^{n} \left(-x_i \sin\left(\sqrt{\lvert x_i \rvert}\right)\right)$	$[-500, 500]^n$	30	$-418.983n$
$f_2(\boldsymbol{x}) = \sum_{i=1}^{n} \left(x_i^2 - 10\cos(2\pi x_i) + 10\right)$	$[-5.12, 5.12]^n$	30	0
$f_3(\boldsymbol{x}) = -20\exp\left(-0.2\sqrt{\frac{1}{n}\sum_{i=1}^{n} x_i^2}\right) - \exp\left(\frac{1}{n}\sum_{i=1}^{n}\cos(2\pi x_i)\right) + 20 + \exp(1)$	$[-32, 32]^n$	30	0

- Note that it is very hard to find the optimal solutions when n = 30. Hence, when testing your program, you can check whether it can find the optimal solution when n = 1.
- Hint
  - 1. (編碼) 設定一個維度變數，設定為30維度
  - 2. (編碼) 改變數上下界low和up
  - 3. (解碼) 改適應度函數成f_1 (因code求最大，此處求最小，加負號)
  - 4. (輸出) 輸出值都改成負的