Extra Problem Set #1

1. Briefly describe Searle's Chinese Room Argument.
2. What are the two dimensions under which approaches to AI can be classified?
3. Present an argument, but not formally prove, that

$$x^* = \arg\max_{x\in\mathbb{R}^n} f(x) = \arg\min_{x\in\mathbb{R}^n} k - f(x)$$

   where $k \in \mathbb{R}$, and $f : \mathbb{R}^n \to \mathbb{R}$

4. Suppose that g is monotonically **decreasing**. Does $\arg\max_{x\in\mathbb{R}^n} f(x) = \arg\max_{x\in\mathbb{R}^n} g(f(x))$?
5. Briefly mention the function of the mutation operator in gradient descent.
6. Suppose that we have an initial temperature of $t_0 = 23.5$ for simulated annealing. Calculate, the temperature schedule for 3 iterations using
   (a) Exponential annealing with $\gamma = 0.8$
   (b) Fast annealing
7. Suppose that we are iteration i with temperature $t_i = 18$. Suppose that we trying to minimise f using simulated annealing and $\Delta f = 5.3$. Compute the acceptance probability.
8. Consider the chromosomes $[2, 3, 3, 5, 6]$ and $[34.4, 5.6, 2.3, 0, 1]$. Both are 0-indexed arrays. Using the above as parent 1 and parent 2 respectively, show the result of the following crossovers:
   (a) Single-point crossover at index 3
   (b) Interpolation crossover at $\lambda = 0.4$
   (c) Uniform crossover with the following random numbers: $0.5, 0.6, 0.1, 0.2, 0.99, 0.05$.
9. Suppose that we have a chromosomes represented as a bit array. Using pseudocode, describe an implementation of the mutation operation for the genetic algorithm.
10. What is the update formula for the velocity in particle swarm optimisation.
11. Suppose that we set the inertia coefficient ω to a very high value in particle swarm optimisation. How this effect the function of the algorithm?
12. Produce the backtracking tree for the $n-$Queens Problem when $n = 2$ and $n = 3$.
13. Trace through gradient descent to minimise the following functions with a learning rate of 0.01. Show only 3 iterations
   (a) $f(x) = 3x^3 - 4x + 5$ starting at $x = 100$
   (b) $f(x, y) = x^2 + 10(y - x^2)^2$ starting at $x = -3, y = -4$
14. Recall that the PMF of the Poisson distribution is $P(x; \lambda) = \frac{\lambda^x e^{-\lambda}}{x!}$. Derive the negative log-likelihood function. You do not describe it in closed-form.
15. Formalise the following optimisation problems:

3.1-7. The Whitt Window Company, a company with only three employees, makes two different kinds of hand-crafted windows: a wood-framed and an aluminum-framed window. The company earns \$300 profit for each wood-framed window and \$150 profit for each aluminum-framed window. Doug makes the wood frames and can make 6 per day. Linda makes the aluminum frames and can make 4 per day. Bob forms and cuts the glass and can make 48 square feet of glass per day. Each wood-framed window uses 6 square feet of glass and each aluminum-framed window uses 8 square feet of glass.

3.4-9. Web Mercantile sells many household products through an online catalog. The company needs substantial warehouse space for storing its goods. Plans now are being made for leasing warehouse storage space over the next 5 months. Just how much space will be required in each of these months is known. However, since these space requirements are quite different, it may be most economical to lease only the amount needed each month on a month-by-month basis. On the other hand, the additional cost for leasing space for additional months is much less than for the first month, so it may be less expensive to lease the maximum amount needed for the entire 5 months. Another option is the intermediate approach of changing the total amount of space leased (by adding a new lease and/or having an old lease expire) at least once but not every month.

The space requirement and the leasing costs for the various leasing periods are as follows:

Month	Required Space (Sq. Ft.)
1	30,000
2	20,000
3	40,000
4	10,000
5	50,000

Leasing Period (Months)	Cost per Sq. Ft. Leased
1	\$ 65
2	\$100
3	\$135
4	\$160
5	\$190

The objective is to minimize the total leasing cost for meeting the space requirements.

3.4-13. The Metalco Company desires to blend a new alloy of 40 percent tin, 35 percent zinc, and 25 percent lead from several available alloys having the following properties:

	Alloy				
Property	**1**	**2**	**3**	**4**	**5**
Percentage of tin	60	25	45	20	50
Percentage of zinc	10	15	45	50	40
Percentage of lead	30	60	10	30	10
Cost ($/lb)	22	20	25	24	27

The objective is to determine the proportions of these alloys that should be blended to produce the new alloy at a minimum cost.

12.1-4. The board of directors of General Wheels Co. is considering six large capital investments. Each investment can be made only once. These investments differ in the estimated long-run profit (net present value) that they will generate as well as in the amount of capital required, as shown by the following table (in units of millions of dollars):

	Investment Opportunity					
	1	**2**	**3**	**4**	**5**	**6**
Estimated profit	15	12	16	18	9	11
Capital required	38	33	39	45	23	27

The total amount of capital available for these investments is $100 million. Investment opportunities 1 and 2 are mutually exclusive, and so are 3 and 4. Furthermore, neither 3 nor 4 can be undertaken unless one of the first two opportunities is undertaken. There are no such restrictions on investment opportunities 5 and 6. The objective is to select the combination of capital investments that will maximize the total estimated long-run profit (net present value).