Problem 1

1) (a) size of the vectors

   $\vec{v}$ = [P x 1]

   $\vec{x}$ = [n x 1]

   $\vec{b}$ = [m x 1]

   (b) $\vec{v} = \vec{0} \in \mathbb{R}^P$

   (c) Optimization problem P

   Min $\vec{v}^t B \vec{x}$

   S.t $A\vec{x} \le \vec{b}$

   $\cancel{\vec{v}^t B \vec{x} \ge 0}$ −2

   $\vec{x} \ge 0$

   Problem (1) can be reformulated as

   Find $\vec{v}$

   S.t P ≥ 0

   (d) No, you can't feed P to an LP Solver and give a solution.

2) (a) $\vec{c} = B^t \vec{v}_0$

   Size of $\vec{c}$ = [n x 1]

   (b) $\vec{x}$ = [1 1 1]'

   $\vec{v}_0^t B \vec{x} = -8$ (Since the value is negative, $\vec{v}_0$ doesn't satisfy the problem

3) (a) Min $\vec{b}^t \vec{y}$

   S.t $A^t\vec{y} \ge -\vec{c}$

   $\vec{y} \ge 0$

   (b) Min $\vec{b}^t \vec{y}$

   S.t $A^t\vec{y} \ge -B^t \vec{v}$

   $\vec{y} \ge 0$

   Yes, this problem can be solved using a LP solver.

(c) Converting the above dual to standard form, we get

Min $\vec{b}^{t}\vec{y}$

S.t $A^{t}\vec{y} + B^{t}\vec{v} \geq 0$

$\vec{y} \geq 0$

Substituting $\vec{y}$ by $\vec{\lambda}$

The Problem becomes,

Min $\vec{b}^{t}\vec{\lambda}$

S.t $A^{t}\vec{\lambda} + B^{t}\vec{v} \geq 0$

$\vec{\lambda} \geq 0$

Since it is a minimization problem we know that value of $\vec{b}^{t}\vec{\lambda} \leq 0$, and the feasible solution for a dual is the feasible solution for primal, therefore since $\vec{v}$ is the solution to the dual problem, it is the solution to problem (1) too.

(d) First solve for x, using random matrix A & vector b.

Then pass the value of the product B and x, to the L1 norm to find the value of v.

We will come to find out that value of v is unbounded, as v can take value.

Prob3d.m is the mat lab code used to solve problem (1).

The value of EXITFLAG will be -3 which implies the problem is unbounded.

Problem 2

1) (a) No we can't find an ***f*** *that* can exactly fit all the data points.

(b) **L1 norm**

min $t_1 + t_2 + t_3 + t_4 + t_5 + t_6 + t_7$

s.t $|ax_1 + b - y_1| \le t_1$

$|ax_2 + b - y_2| \le t_2$

$|ax_3 + b - y_3| \le t_3$

$|ax_4 + b - y_4| \le t_4$

$|ax_5 + b - y_5| \le t_5$

$|ax_6 + b - y_6| \le t_6$

$|ax_7 + b - y_7| \le t_7$

$t_1, t_2, t_3, t_4, t_5, t_6, t_7 \ge 0$

L∞ norm

min t

s.t $|ax_1 + b - y_1| \le t$

$|ax_2 + b - y_2| \le t$

$|ax_3 + b - y_3| \le t$

$|ax_4 + b - y_4| \le t$

$|ax_5 + b - y_5| \le t$

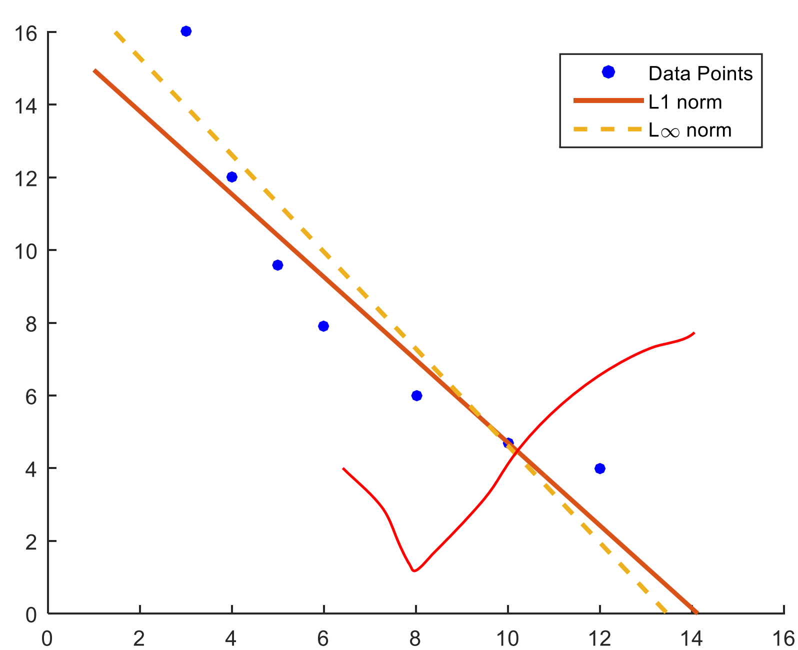
$|ax_6 + b - y_6| \le t$

$|ax_7 + b - y_7| \le t$

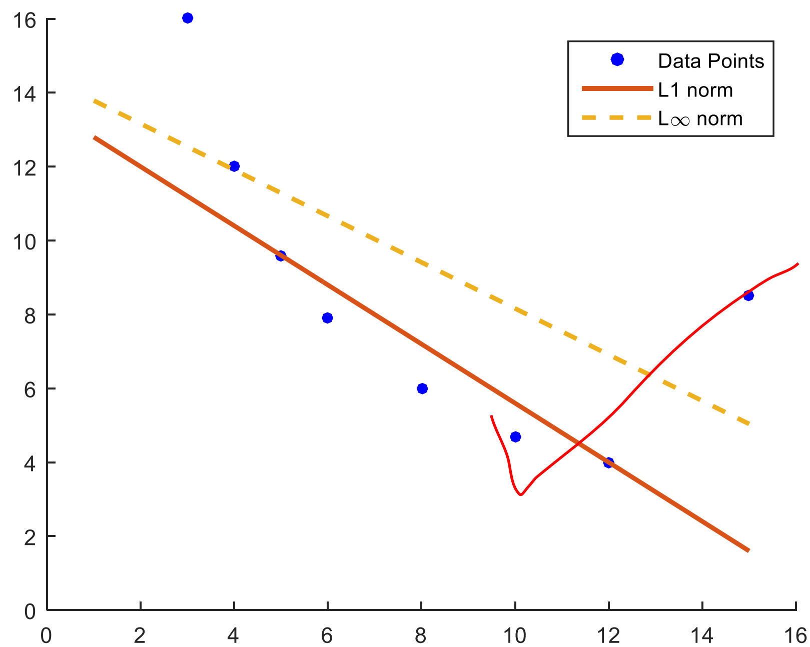
$t \ge 0$

(c) Script **prob1.m** and functions **L1norm.m, LInfnorm.m, nDegreePolynomial.m & plotGraph.m** are used to solve the given problem.

First call **prob1.m** and you will get a prompt saying "**enter the value of n:**" give 1 for this prob.



(d) For this problem call prob2.m and enter the value for n as 1.



By comparing the above two figures we could see that L∞ norm is very sensitive and L1 norm is insensitive to presence of outliers

2) (a) **L1 norm**

min $t_1 + t_2 + t_3 + t_4 + t_5 + t_6 + t_7$

s.t $|a_1x_1 + a_2x_1^2 + b - y_1| \leq t_1$

$|a_1x_2 + a_2x_2^2 + b - y_2| \leq t_2$

$|a_1x_3 + a_2x_3^2 + b - y_3| \leq t_3$

$|a_1x_4 + a_2x_4^2 + b - y_4| \leq t_4$

$|a_1x_5 + a_2x_5^2 + b - y_5| \leq t_5$

$|a_1x_6 + a_2x_6^2 + b - y_6| \leq t_6$

$|a_1x_7 + a_2x_7^2 + b - y_7| \leq t_7$

$t_1, t_2, t_3, t_4, t_5, t_6, t_7 \geq 0$

L∞ norm

min t

s.t $|a_1x_1 + a_2x_1^2 + b - y_1| \leq t$

$|a_1x_2 + a_2x_2^2 + b - y_2| \leq t$

$|a_1x_3 + a_2x_3^2 + b - y_3| \leq t$

$|a_1x_4 + a_2x_4^2 + b - y_4| \leq t$

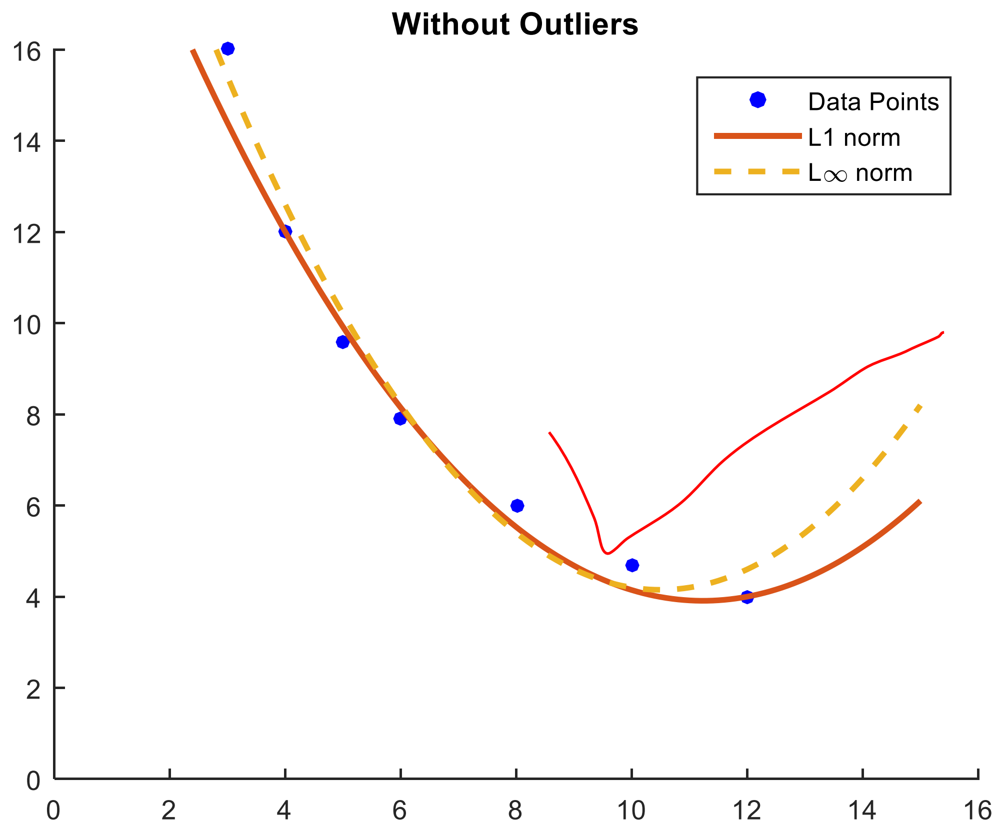
$|a_1x_5 + a_2x_5^2 + b - y_5| \leq t$

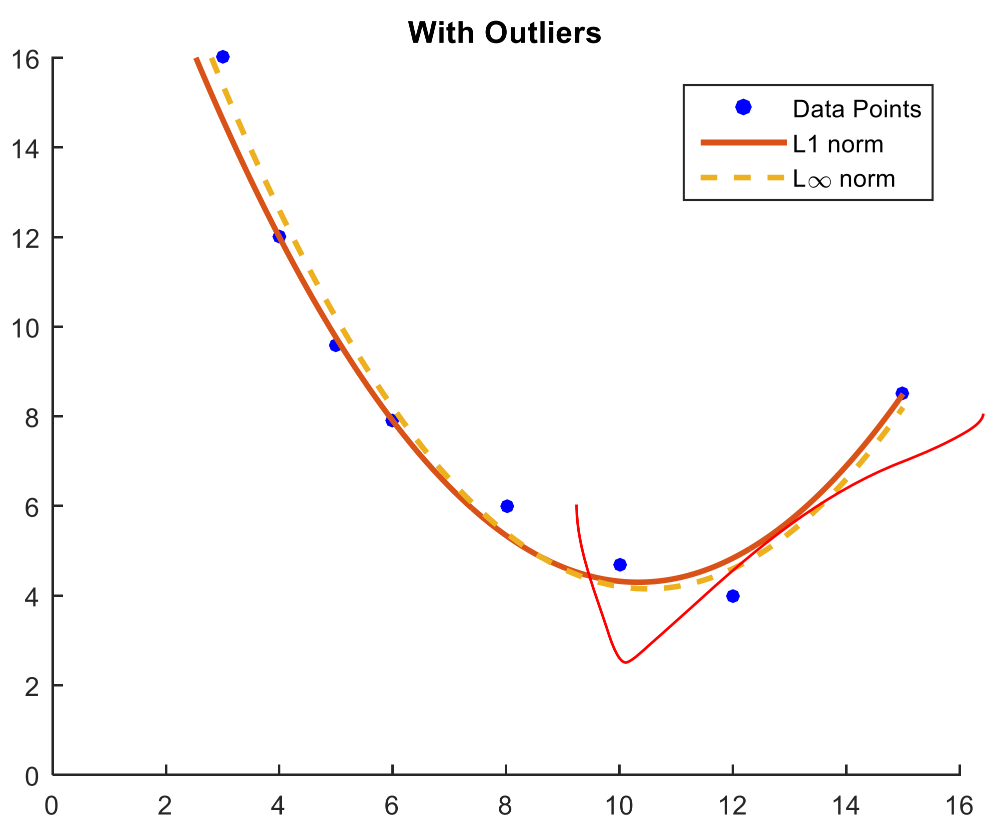
$|a_1x_6 + a_2x_6^2 + b - y_6| \leq t$

$|a_1x_7 + a_2x_7^2 + b - y_7| \leq t$

$t \geq 0$

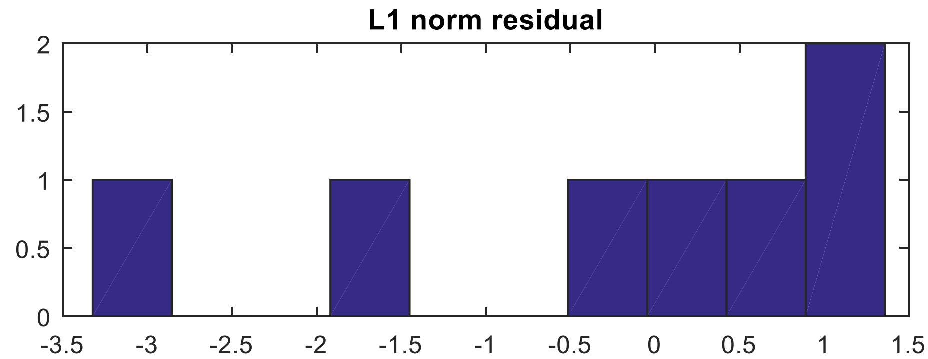
(b) As stated above, call prob1.m and prob2.m but give the value of n as 2.

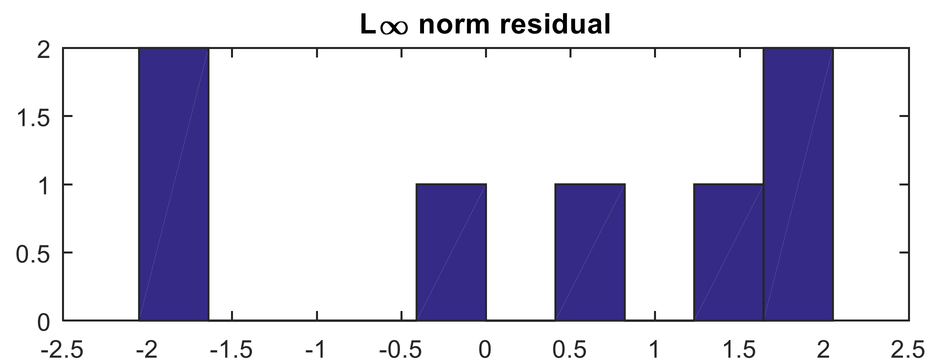




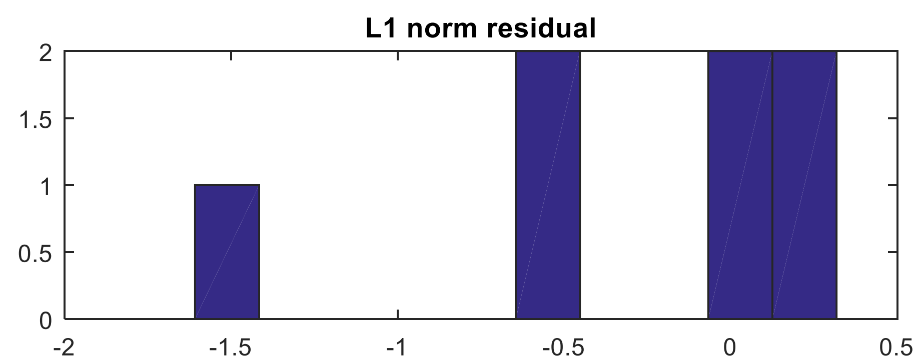
(c) Performance of the affine and the polynomial model for each norm can be inferred from the below Error Histograms

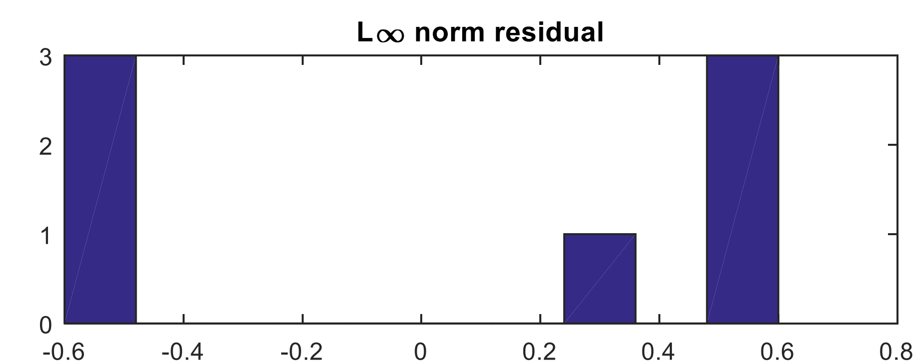
For n = 1 (Affine Model)





For n=2 (Polynomial Model)





3) **nDegreePolynomial.m** function handles polynomial models with up to a degree N that will be given as an input.