# COMPGV19:Numerical Optimisaton
# Assignment 7

Keshav Iyengar

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## 1 Exercise 1

Submitted via cody coursework.

## 2 Exercise 2

Optional.

## 3 Exercise 3

a) The least squares problem is formulated as follows.

$$\tilde{\phi}(x_1, x_2, x_3; t) = \phi(x_1, x_2, x_3; t) + n(t)$$

$$\phi(x_1, x_2, x_3; t) = (x_1 + x_2 t^2) e^{-x_3 t}$$

$$n(t) \sim \eta(0, \sigma)$$

$$\sigma = 0.05\texttt{max}(|\tilde{\phi}(t)|)$$

Using the $p\tilde{h}i$ measurement model, measurements were created. $(x_1, x_2, x_3) = (3, 150, 2)$ with $t_i \epsilon (0, 4]$ with $m = 200$ equally spaced points. Let $y_i$ represent each measurement. $\sigma$ was found to be 1.0357.

$$\frac{1}{2}\sum_{j=1}^{m}(\phi(x_1, x_2, x_3; t_j) - y_j)^2$$

The residual is then defined as

$$r_j(x_1, x_2, x_3; t_j) = \phi(x_1, x_2, x_3; t_j) - y_j$$

Deriving the jacobian

$$\frac{\partial r_j}{\partial x_1} = e^{-x_3 t}$$

$$\frac{\partial r_j}{\partial x_2} = t^2 e^{-x_3 t}$$

$$\frac{\partial r_j}{\partial x_3} = -x_1 t e^{-x_3 t} + (-x_2 t^3 e^{-x_3 t})$$

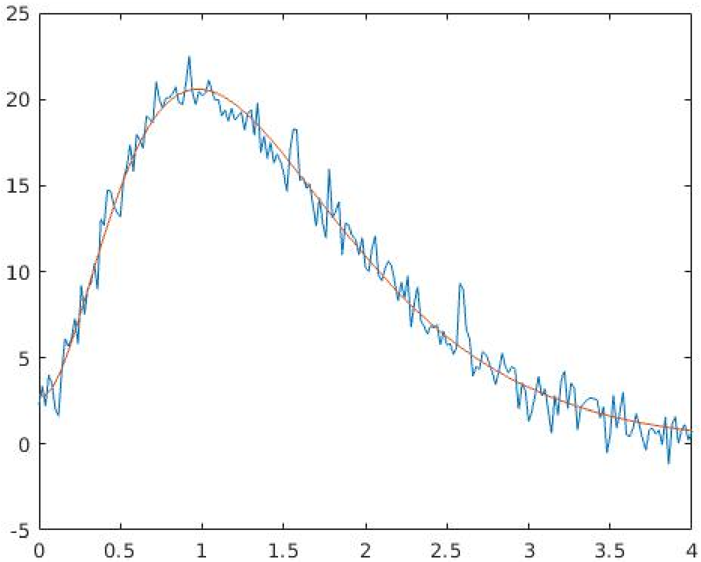
$$J = \begin{bmatrix} \frac{\partial r_1}{\partial x_1} & \frac{\partial r_1}{\partial x_2} & \frac{\partial r_1}{\partial x_3} \\ \frac{\partial r_2}{\partial x_1} & \frac{\partial r_2}{\partial x_2} & \frac{\partial r_2}{\partial x_3} \\ \vdots & \vdots & \vdots \\ \frac{\partial r_m}{\partial x_1} & \frac{\partial r_m}{\partial x_2} & \frac{\partial r_m}{\partial x_3} \end{bmatrix}$$

b) (i) Gauss Newton Parameters

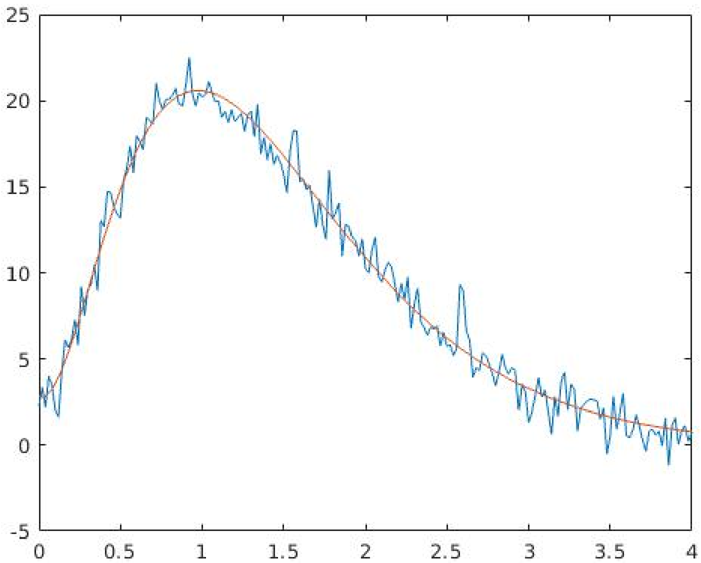
```
% Parameters
x0 = [3;150;2];
maxIter = 200;
tol = 1e-10;
% Line search parameters
alpha0 = 1;
% Strong Wolfe LS
lsOpts_LS.c1 = 1e-4;
lsOpts_LS.c2 = 0.5;
```

(ii) Levenberg-Marquardt

```
% Trust region parameters
eta = 0.1;  % Step acceptance relative progress threshold
Delta = 1; % Trust region radius
debug = 0;
maxIter = 200;
tol = 1e-10; % Stopping tolerance on relative step length between iterations
x0 = [3;150;2];
```




(a) Measurements(blue) and Gauss-Newton Solution (red)




(b) Measurements(blue) and Levenberg-Marquardt Solution (red)

Figure 1: Gauss-Newton and Levenberg-Marquardt Solutions