# Module 4 Assessment - Part 2 (incl. MATLAB)

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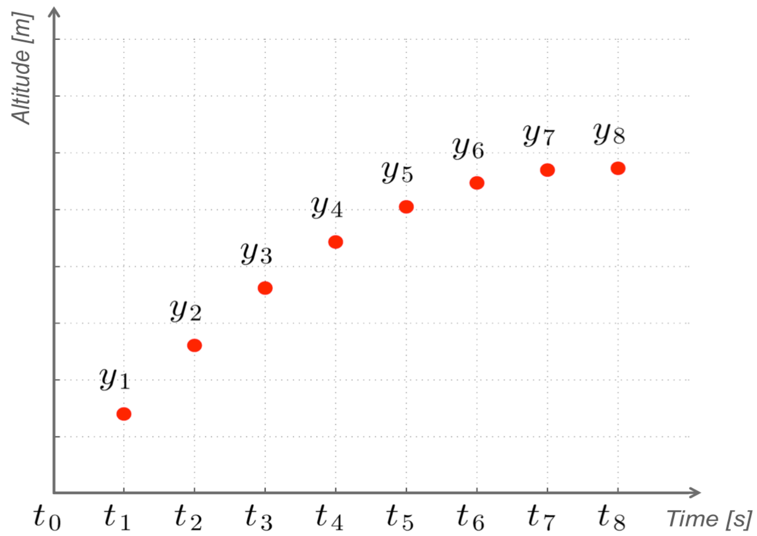
You have eight observations of the altitude of a ballistic body at different trajectory time (see the following figure).




The observations at each time instant is given as:

Time [seconds]: $[1,\ 2,\ 3,\ 4,\ 5,\ 6,\ 7,\ 8]$

Observed heights [meters]: $[79.06,\ 126.13,\ 179.90,\ 218.77,\ 258.74,\ 266.91,\ 274.91,\ 280.61]$

Q&A Forum

4.ⓔ Non-linear Least Squares (optional topic)

Feedback

- 5. How precise is the estimate?
- Pre-knowledge Mathematics
- MATLAB Learning Content

In the most basic case, the altitude of the ballistic body can be explained by the quadratic function of time:

**Model**: $y_i = x_0 + x_1 t_i + \frac{1}{2} x_2 t_i^2$

where

$x_0$ is the initial altitude, $x_1$ is the initial velocity, and $x_2$ is the gravitational acceleration.

The precision of observations is growing by time as $\sigma_{y_i} = 10\sqrt{t_i}[\mathrm{m}]$. The observations are uncorrelated.

We are mainly interested in the BLU estimate of the gravity acceleration.

In the following MATLAB assignment, you should make the design matrix and the covariance matrix of observations, and finally estimate the BLU of the model parameters.

## BALLISTIC BODY (MATLAB EXERCISE) (EXTERNAL RESOURCE)

# BALLISTIC BODY (MATLAB EXERCISE)

See the introduction above.

Apply ordinary BLU estimation and calculate the best linear inbiased estimation of the gravity acceleration.

## Your Solution

Save Reset MATLAB Documentation (https://www.mathworks.com/help/)

```
% Times of observation [seconds]
t = [1,2,3,4,5,6,7,8]';
% Observed altitude [m]
y = [79.06, 126.13, 179.90, 218.77, 258.74, 266.91, 274.91, 280.61]';

% Number of observations
m = length(t);

% Design matrices for the two models
A = [ones(m,1), t, 0.5*t.^2];

% Covariance matrix
Q = 100*t.*eye(m);

% What is the bset linear unbiased estimation of the model parameters
xhat = (A'*inv(Q)*A) \ A'*inv(Q)*y %inv(A'*inv(Q)*A)*(A'*inv(Q)*y);
xhat

figure, plot(t,y,'.b','markersize',20), hold on; grid on
plot(t,A*xhat,'r','linewidth',2)
set(gca,'xlim',[0 max(t)+1])
set(gca,'ylim',[0 1.4*max(y)])
xlabel('time [s]')
ylabel('altitude [m]')
legend('observations','model')
```

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## BLUE of the gravitational acceleration

4/4 points (graded)

What is the BLU estimate of the gravitational acceleration in $[m/s^2]$ (give answer to three decimal places)?

-8.984

✔ **Answer:** -8.984

$-8.984$

Submit You have used 1 of 1 attempt

✔ Correct (4/4 points)