

**Reading Topic 3:** One or more of the following (or equivalent).

- Venables, W.N. and Ripley, B.D. (2002). Modern Applied Statistics with S, Springer. Chapters: 10
  - Searle, S. R. and McCulloch, C.E, Generalized, linear and mixed models, New York, Wiley, 2001.  
chapter(s) 6 & 8
  - Verbeke, G. and Molenberghs, G., Linear Mixed Models for Longitudinal Data, Springer, 2000.
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**Assignment 5: For 8% module credit (MSc group);  
20% Module credit (PhD group)**

Submission deadline: 6.30pm Monday 4th April - hard-copy only!

1. Give the general log likelihood for a linear mixed model and show how the regression parameters may be profiled out of this likelihood to give a reduced log likelihood in terms of the variance components only.

[15 marks]

2. Give the update formulae used in applying the Newton-Raphson method for fitting a linear mixed model. Explain all terms used.

[15 marks]

3. The data shown in Table 1 is a portion of dataset recording the a particular variable of dental growth measured from 11 boys and 16 girls. The measurement were repeated at ages 8, 10, 12 and 14.

The response variable was the distance in mm from the centre of the pituitary to the pteryo-maximillary fissure. This distance is the relative distance of the two points and may occasionally decrease between ages.

Table 1. Dental growth data.

person	gender	distance	age
1	F	21	8
1	F	20	10
1	F	21.5	12
1	F	23	14
⋮	⋮	⋮	⋮
13	M	21.5	8
13	M	22.5	10
13	M	23	12
13	M	26.5	14
⋮	⋮	⋮	⋮

The full dataset called ‘PR\_growth.csv’ is on the Webcourses module.

Conduct an analysis of these data, considering the fixed effects of gender and age (with possible interaction?). You should also consider the possibility of dependence here and explore this using suitable models. Present a short data analysis report outlining your findings and append to this report the **R** programme you used for the analysis.

[70 marks]