Install the MEMSS package that contains data sets from the book "Mixed-effects Models in S and S-PLUS" that I wrote with José Pinheiro.

1. Check the structure of the `Rail` data and the documentation for it. It is a simple, one-factor, balanced design, similar to the `Dyestuff` data.

   (a) Plot the data in a form that seems appropriate - perhaps a dotplot by `Rail` sorted by increasing `travel` time joining the means of the travel times. Note that you probably don't want to use a comparative boxplot because there are only three observations per rail and you don't want to "summarize" three observations with five summary statistics.

   (b) Fit a model with `travel` as the response and a simple, scalar random-effects term for the variable `Rail`. Use the REML criterion, which is the default. Check the dotplot (i.e. the "caterpillar" plot) for the random effects.

   (c) Refit the model using maximum likelihood. Check the parameter estimates and, in the case of the fixed-effects parameter, its standard error. In what ways have the parameter estimates changed? In particular, which parameter estimates have not changed?

2. Consider the `ergostool` data; check its stucture and summary. The stool types are fixed, the subjects in the experiment are chosen at random. The structure of the data are similar to the `Penicillin` data (unreplicated, completely crossed) but here we will consider the `Type` factor to have fixed levels.

   (a) Plot the data. You may want to consider a plot similar to that of the `Penicillin` data shown on the slides.

   (b) Fit a mixed-effects model to these data with fixed-effects for `Type` and a simple, scalar random effect for each level of `Subject`. A suitable formula could be

   ```
   effort ~ 1 + Type + (1 | Subject)
   ```

   What does the `(Intercept)` coefficient represent? What do the other fixed-effects terms represent? Change the formula to

   ```
   effort ~ 0 + Type + (1 | Subject)
   ```

   which suppresses the intercept term. What do the fixed-effects parameters represent now?

   (c) Fit a model with random effects for `Type` and for `Subject`. Check the fixed-effects parameter (the `(Intercept)` and the conditional means of the random effects. Check the caterpillar plot for the random-effects for the `Type` factor. How do the random effects compare to the corresponding fixed-effects parameters from the previous part in precision and position?

3. The `MathAchieve` data are similar to the `classroom` data but with school identifiers only. The variable `MEANSES` is the mean socio-economic status for students in the school.

   (a) Check that `MEANSES` is defined consistently within a school. That is, check that each school has exactly one value for `MEANSES`.

   (b) Determine the distribution of the number of students per school. You can use `xtabs` to get a count of the number of students in each school, then summarize that distribution, perhaps by a densityplot. Do you think you will be able to estimate school effects reasonably precisely?

(c) Fit a model with fixed effects for `Sex`, `Minority` and `MEANSES` and simple scalar random effects for `School`. Compare the magnitudes of the estimates for the `Sex` and `Minority` terms to the shifts that you might observe in, say, comparative density plots.

(d) Check the caterpillar plot of the random effects for school. Are there schools that seem clearly better or clearly worse than the typical school?

(e) Fit a model with the previous fixed-effects term plus a Sex/Minority interaction term. A suitable formula would be

```
MathAch ~ Sex * Minority + MEANSES + (1 | School)
```

Is the interaction term significant?

(f) (Optional) Other school-level covariates are given in the data frame `MathAchSchool`. Consider how you could merge these with the current variables (see `?merge`). Examine these variables both graphically and by fitting and comparing models.

4. Consider the `RatPupWeight` data. Check its structure and a summary.

(a) Plot the data using an xyplot of the weight versus litter size with scatterplot smoother lines according to sex. Do you think there will be significant effects on weight due to the litter size and to the sex of the pup?

(b) Consider the pattern with respect to litter size. Replot versus the logarithm of the litter size. Does that enhance the linearity of the plot?

(c) Plot weight versus litter size or logarithm of litter size, whichever seems reasonable to you with groups according to the treatment. Do you expect significant effects due to treatment?

(d) Fit a mixed-effects model with random effects according to litter and with whatever fixed-effects terms you consider appropriate. Expand or contract the model as you see fit.

(e) Notice the outlier — one rat pup was unusually low weight. Investigate the effect on your conclusions of omitting this observation.

5. Consider the `Wheat` data. Check its structure, summary and documentation.

(a) Plot the `DryMatter` by `Moisture` with groups for fertilizer. Try a log transformation of the `DryMatter`. Does that help to stabilize the patterns?

(b) Fit and analyze a mixed-effects model with random effects for `Tray`.