1. The *surface finish* of metal parts made on $a = 4$ machines is under investigation. Each machine can be run by one of $b = 3$ operators. Because of the location of the machines, operators are specific to a particular machine. Therefore, a nested design with fixed factors is used. Each operator produces $n = 2$ samples. The data is availabe on Blackboard as an Excel File.

(a) Explain the difference between crossed factors and nested factors.
(b) Write the model for a nested design. Provide algebraic formulas for the estimates $\widehat{\tau}_i$ and $\widehat{\beta}_{j(i)}$.
(c) Compute the F_A statistic for testing factor A effects, and the $F_{B(A)}$ statistic for testing nested factor B effects. Compute the p-values. Provide an overall interpretation, stated in the context of the problem.
(d) Compute estimates for each of the effect parameters. Identify which machine performs best, and which operator performs best on each machine. (Higher scores of response are preferred.)
(e) Explain why it is not possible to directly compare operators across machines in the above design.

2. A nested design is used to study the *burning rate* of propellant from three production processes (fixed effect, factor A). Four batches of propellant are randomly selected from each of the processes (random effect, factor B), and $n = 3$ determinations of burning rate are made on each batch. The data is availabe on Blackboard as an Excel File.

(a) Provide the algebraic formulas for MSA, $MSB(A)$, and MSE.
(b) State the expected value for each of the mean squares.
(c) Test for differences between the production processes. Write the F_A statistic as a ratio of mean squares. Compute F_A and the p-value. Provide an interpretation, stated in the context of the problem.
(d) Explain why MSE is the incorrect error term to use when the nested factor is random. In particular, comment on the pertinent sample size.
(e) Illustrate how evidence in favor of a process effect would be overstated if MSE is used when computing the test statistic.
(f) Compute estimates of the batch variance and the measurement variance.