# Student name: …

# Background

Use Matlab and Simulink to solve tasks below.

Use the example scripts in “Assign3.zip” uploaded at Canvas. Use the latest version published

The main Simulink model is “EDR100\_Model3.slx”.

Good practice for plots:

* Give the plot a descriptive title, e.g. to know what the data source is.
* Always label all axes with physical quantity and the relevant unit.
* Try to scale the data with prefixes (milli, kilo…) so that the data labels on the axes are as short as possible, and hence easy to read.
* Simulink plots will include labels if you manually label the signals going in to the scope, and enable “lagend” in the scope options.

MathWorks offer excellent help sections for Matlab and Simulink. Try typing “doc plot” in the command window to open the help section for plotting. There’s also vast archives of Q&A available online through MathWorks forums, StackExchange and many more.

Example of a great plot:

Chart, surface chart

Description automatically generated

# Tasks

1. Extract the MotorCAD data from 'Nissan\_Leaf\_Sample\_Data.mat' and use ‘import\_MotorCAD\_data.m’ to make 3D-plots over the following data (paste a plot picture as the answer), with rotational speed and torque as the x and y axis.
2. Total efficiency in percent (2)
3. Phase Voltage in Volts RMS (2)
4. Phase Current in Amperes RMS (2)
5. Power Factor in percent (2)
6. Total Losses in kW (2)
7. Output mechanical power at the EM shaft (2)
8. Answer the following questions by analyzing the data in task (A). Data analysis can be numerical, using e.g. Matlab ‘max’, ‘find’, or it can be visual inspection by carefully analyzing all angles of the 3D graphs and picking the requested values.
9. What is the highest rotational speed of the EM? (1)
10. What is the highest torque output of the EM? (1)
11. What is the highest efficiency, and at what operating point (speed, torque) can it be found? (2)
12. What is the lowest phase RMS voltage? (1)
13. What is the highest phase RMS voltage, and can you describe what operating points this is found (e.g. mark it by sketching in the 3D plot and paste it below)? (2)
14. What is the lowest and highest phase RMS current? (2)
15. What is a typical value for the power factor for this machine? I.e. what is a common range of power factor values for most operating points? (2)
16. What is the highest output (mechanical) power and what operating point (speed, torque) is it? (2)  
    Hints:   
    It is not necessary Max torque \* speed at that torque!   
    Definitely **not** max torque \* max speed, those two do not occur at the same time!
17. Open the Simulink model as it came in the zip file. You find all automatically loaded parameters in “init\_Model3.m”.
18. Insert a scope in the Simulink model showing vehicle speed, gearbox losses, EM losses (remember labels on axes). Run the model and insert a picture of the scope as the answer to this question. (2)
19. How high are the peak loss power (in W) for EM and transmission in the WLTC? (2)
20. Add blocks in the Simulink model to calculate the loss energy (in Joule) for EM and transmission. At the end of the simulation (last step of the drive cycle), which component has the biggest accumulated energy loss? Add a picture of the plot/scope of the relevant signals. How much bigger is the smaller loss compared to the second smallest component? (3)
21. Change the gearbox ratio by modifying the value of “gear\_ratio” in the “init\_Model3.m” file. Insert a scope that plots the EM torque and speed, and keep an eye open for errors in the diagnostic menu at the bottom of the Simulink window and the Matlab command window. Try many different gear ratios, higher and lower than the original 8.0 and see what happens with the model!
    1. What is the lowest gear ratio you can run the simulation with? Find the value with one decimal. What happens with lower gear ratios, and what does it mean? (2)
    2. What is the highest gear ratio you can run the simulation with (one decimal)? Note that the number will not be unreasonably large like over a hundred. What happens with higher gear ratios? (2)
22. Typical gearbox designs. Look through the first 13 minutes of the video from Prof. Kelly: <https://youtu.be/SRUrB7ruh-8> and answer the questions below.
    1. What are the sizes of the cogwheels, counted in number of teeth per cogwheel? (1)
    2. How many gear stages are used, i.e. how many *pairs* of cogwheels directly interact with each other? (1)
    3. What is the total gear ratio? Answer in decimals. (1)
    4. In what Tesla models is this design used? (1)
23. Analytical sizing of gearbox
    1. Decide a maximum vehicle speed of your car (in the range of 160-250 km/h) (1)
    2. Use the effective wheel diameter (d\_wheel or r\_wheel in Workspace) to calculate the highest wheel axle speed occurring at the max vehicle speed (answer in both rpm and rad/s) (1)
    3. Use the max EM speed from the Nissan Leaf tasks above. Calculate the highest possible gear ratio of your gear box that will keep the EM operating point below the maximum allowed rotational speed. Include your calculations. (2)
    4. What are the consequences on EM if we decide to use a gearbox with a lower gear ratio than the one calculated in the previous question (performance: torque, speed, efficiency, size)? Reason, calculate, motivate, and/or you may use picture or graph to explain. (2)