MA103: Mathematical Modeling
Model Assessment I **08 October 2025**

1. Use a first principles approach to select the appropriate model family
2. Use a first principles approach to select appropriate parameters for a model
3. Use an empirical approach to select the appropriate model family
4. Use an empirical approach to select appropriate parameters for a model
5. Use SSE and R^2 to assess and compare models

Warm-Up Exercise:

Determine which type of model, linear or exponential, best represents the following problem types. Then make a decision: Should we solve with a first-principle or empirical approach? Write down the relevant equations associated with this approach and discuss why you have made the decision.

1. Currently, there are 1000 bacteria in every cadet's sink. Your friend from another regiment measured how many bacteria remained in his sink every hour after he sprayed it at 0000 hours the night before SAMI. Use the table below to answer the following questions.

Hour	0	1	2	3	4	5
Number of Bacteria	1000	500	250	125	62.5	31.25

Table 1: Bacterial Population Over Time

UPDATE: If you were given a growth rate and initial population, how would your solution change?

2. Model the balance of a $1000 investment in a savings account using the following data. Predict the account balance after 30 years

Year	0	1	2	3	4	5	6	7
Balance ($)	1000	1051.27	1105.17	1161.83	1221.40	1284.03	1349.86	1419.07

Table 2: Account Balance Over 8 Years

UPDATE: If you were given a interest rate and initial investment, how would your solution change?

Example Problem:

You are assisting a logistics officer who wants to predict fuel usage for convoys of different lengths. Two analysts propose different models:

- Analyst A suggests that fuel increases linearly with distance.
- Analyst B suggests that fuel increases exponentially due to load shits and terrain.

You're given the data from 10 test drives and must determine which model is more appropriate. Consider:

1. R^2 and SSE
2. Extrapolation behavior: which one performs better in the long term?
3. Operational realism: which model leads to better decisions?

Distance (km)	Fuel Used (L)
0	4.5
10	7.8
20	9.9
30	12.8
40	17.8
50	21.4
60	22.9
70	27.0
80	29.4
90	31.4

Practice Problems:

1. An engineering team is evaluating electricity consumption for a new production line. As the equipment runs longer, it draws more power. One analyst claims this relationship is linear due to the constant load, while another suggests it grows exponentially due to heat buildup and reduced efficiency. Use the data to determine which model is more appropriate, then make a recommendation for use in planning energy budgets for 12 hour shifts.

Hours Operated	Electricity Used (kWh)
0	2.25
1	3.00
2	5.01
3	6.48
4	8.43
5	9.89
6	11.76
7	13.01
8	14.72
9	16.42

UPDATE: Predict the usage of electricity for 12 hours of operation. How are you using your model, when considering that you are forecasting electricity usage for a value outside of the data domain?

2. A homeowner reports a flooding event in their basement. Water levels were recorded hourly by a smart sensor. Emergency services need a model to forecast how much time they have before the water reaches electrical outlets (at 80cm). You are asked to determine whether a linear or exponential model better reflects the data. Recommend a model type and then estimate the time at which the water level will exceed 80cm.

Time (hrs)	Water Level (cm)
0	6.4
1	6.2
2	9.7
3	12.4
4	17.3
5	24.0
6	30.1
7	37.0
8	47.2
9	59.0

UPDATE: Predict the water level for 5.5 hours. How are you using your model, when considering that you are forecasting water value for a value within the data domain?