1. **Name of Course:** Machine Learning 2 (MSc) / Advanced Machine learning (BSc)

2. **Instructor: Petra Kralj Novak**

3. **No. of Credits (US/ECTS): 2 US / 4 ECTS**

4. **Academic term:** *Winter*

5. **Course level:** *BA / BSc, MSc*

6. **Relationship with other courses**: A prerequisite for this course is the "Introduction to machine learning course" (or equivalent) and basic programming skills (e.g. Introduction to Programming in Python).

7. **Course type:** *Mandatory elective*

8. **Name of the module in which the course is offered:**
   BSc Data Science and Society, MSc Social Data Science

9. **Short description and the overall aim of the course:**
   This course aims to introduce students to advanced topics in machine learning, like handling complicated data, neural network architectures and trustworthiness issues in machine learning. They will gain proficiency in applying these techniques to real-world problems, evaluating their performance critically, and interpreting results effectively. Additionally, students will develop an understanding of the ethical nuances in artificial intelligence, focusing on fairness, transparency, and bias mitigation. The course's overarching aim is to equip students with the technical skills and ethical judgement needed to apply machine learning in social science applications.

10. **The learning outcomes of the course:**
    Upon completion, students will possess a deep understanding of machine learning theories, algorithms, and pitfalls. They will master various algorithms, evaluate their performance, and interpret results effectively. Additionally, students will gain insights into ethical challenges in AI, focusing on fairness and transparency. Equipped with these skills, they will adeptly apply machine learning techniques in social science applications, demonstrating both technical proficiency and ethical awareness.

11. **Learning activities and teaching methods:**

    Lectures, hands-on exercises, project work.

12. **Assessment:**
    - Group project (report + presentation): 50%
    - Quiz: 50%

13. **Course contents:**

    Week 1: Foundations of Machine Learning
    - Review of basic machine learning concepts
    - Understanding data leakage and how to prevent it in machine learning models
    - Feature selection methods

Week 2: Handling unbalanced classes and concept drifts
- Oversampling, SMOTE, artificial data imputation
- Data streams and online learning

Week 3: Complex data types
- Ordered classes
- Multi-label and multi-target prediction
- Complex input: graphs, images ,…

Week 4: Comparing and evaluating models
- Comparing classifiers
- Learning with disagreement

Week 5: Recommender systems
- Collaborative filtering
- Content-based recommendations
- Hybrid methods

Week 6: Applications of stochastic gradient descent
- From linear regression to logistic regression
- Support Vector Machines (SVM)
- Neural networks and deep learning
- Deep neural networks architecture and training techniques
- Overfitting prevention: dropout, regularization
- Batch normalization

Week 7: Deep learning - Convolutional neural networks
- Convolutional operation
- Common CNN Layers: Convolutional layers, activation functions (ReLU), pooling layers (max-pooling), fully connected layers.
- Data augmentation
- Introduction to transfer learning

Week 8: Recurrent Neural Networks, Transformers, and Attention
- Overview of sequence models
- Long Short-Term Memory (LSTM) and Gated Recurrent Unit (GRU) architectures
- Transformer architecture
- Attention mechanism

Week 9: Language Models
- Pre-training: Word Embeddings, Contextual Embeddings
- Fine-tuning
- Best Practices and Case Studies

Week 10: Trustworthy AI and Fairness
- Trustworthy AI principles
- Biases in machine learning
- Interpretability and explainability in machine learning
- Shapley values for feature importance and model interpretability

Week 11: Written exam
Week 12: BSc Projects presentations

14. **Technical requirement:** A computer with Anaconda, we will use Python (and install libraries Pandas, ScikitLearn, PyTorch,…) and Orange (https://orangedatamining.com/)

15. Use of generative AI tools:

AI (artificial intelligence) resources such as ChatGPT and GitHub Copilot can be useful in a number of ways. Because it can also be abused, however, you are required to acknowledge use of AI in any work you submit for class. Critical judgement is required when using content (text, images, code, ..) generated by AI. All uses of AI must be clearly described at the end of each assignment. A student should always be able to explain what his/her code does, all variable types at all times, simulate the run of the program and modify the code.