1. **Course Number and Course Title:**
   MLR510 Generative Deep Learning

2. **Credit Hours:** 3–0–3

3. **Prerequisites and/or Co-Requisites:**
   Prerequisite: Approval of Department Head Concurrent: None
   Competencies: Programming skills and undergraduate courses in Probability and Statistics.

4. **Name and Contact Information of Instructor:**
   Dr. Imran Zualkernan Office: ESB-2063
   Email: izualkernan@aus.edu Phone: (06) 515-2953
   Office Hours: Posted on office door and *iLearn*; also by appointment

5. **Course Description (Catalog Description):**
   Presents the principles of generative deep learning. Covers foundational networks like multi-layer perceptron and convolutional neural network (CNN). Examines generative learning techniques like autoencoders/variational autoencoders (VAE), and various types of generative adversarial networks (GAN). Includes examples using state-of-the-art software.

6. **Textbook and other Supplemental Material:**
   Textbook:
   - Rowel Atienza, *Advanced Deep Learning with TensorFlow 2 and Keras: Apply DL, GANs, VAEs, deep RL, unsupervised learning, object detection and segmentation, and more,* 2nd edition, Packt Publishing, 2020, ISBN-13: 978-1838821654.
   - David Foster, *Generative Deep Learning*, 2nd Edition, May 2023, O'Reilly, Media, Inc., ISBN: 9781098134181
   - Omar Sanseviero, Pedro Cuenca, Apolinário Passos, Jonathan Whitaker, *Hands-On Generative AI with Transformers and Diffusion Models*, 2024, O'Reilly, Media, Inc.

   Other recommended books:
   - Jakub Langr and Vladimir Bok*, GANs in Action: Deep learning with Generative Adversarial Networks*, Manning Publisher, 2019, ISBN-13: 9781617295560.
   - David Foster*, Generative Deep Learning: Teaching Machines to Paint, Write, Compose, and Play,* 1st edition, O'Reilly Media, 2019, ISBN-13: 978-1492041948.
   - Jay Alam mar, Maarten Grootendorst, *Hands-On Large Language Models,* 2024, O'Reilly, Media, Inc.
   - Sebastian Raschka, *Build a Large Language Model (From Scratch)*, Mannings Publisher, 2024.
   - Ben Auffarth, *Generative AI with LangChain,* Packt Publishers, 2024.

   Supplemental material:
   - Deep learning software (free, open source).
   - Selected articles, journal papers, and data sets.

7. **Course Learning Outcomes:**
   Upon completion of the course, students will be able to:
   1. Formulate generative modeling problems and algorithms
   2. Analyze variational autoencoders.
   3. Design generative adversarial networks.
   4. Evaluate various autoregressive models.
   5. Dissect normalizing flow models.
   6. Build diffusion models.
   7. Appraise energy-based models.

8. Communicate current research results in generative deep learning effectively.
9. Assess the ethics of Generative AI

8. Teaching and Learning Methodologies:
Methods include lectures, problem and project-based learning methods (assignments, exams, survey paper, research project, presentation), and class discussions.

9. Course Topics and Schedule:

Topic	Week #
Introduction to Generative AI	1
Background: Convolutional Neural Network	2
Background: Convolutional Neural Network	3
Autoencoders and Variational Autoencoders	4
Introduction to Generative Adversarial Networks (GAN)	5
Wasserstein GANs and Conditional GANs	6
Autoregressive Models: RNN and LSTMs	7
Normalizing Flow models	8
Energy-based models	9
Diffusion models	10
Applications: Transformers	11
Applications: GPT and similar models	12
Applications: Advanced GANS	13
Applications: Music Generation	14
Class Presentations	15
Final Exam	16

10. Schedule of Laboratory and other Non-Lecture Sessions:
Not applicable.

11. Out-of-Class Assignments with Due Dates:

Assignment	Due Date
Homework 1: Implementing and analyzing a variational autoencoder	Week 6
Homework 2: Implementing and analyzing a GAN	Week 7
Homework 3: Implementing and analyzing an LSTM	Week 8
Homework 4: Implementing and analyzing a normalizing flow model	Week 9
Homework 5: Implementing and analyzing an energy-based model	Week 10
Homework 6: Implementing and analyzing a diffusion model	Week 11
Theme-based survey paper	Week 8
Research project	Week 15

12. Student Evaluation:

Assessment	Weight	Due Date
Homework	15%	Cf. Section 11
Class presentation of one current research paper	10%	Week 15
Survey report on a theme around generative learning	10%	Cf. Section 11
Research project	30%	Cf. Section 11
Final Exam	35%	Week 16

In the research project, due at the end of the semester, students are given a real-world data set and must apply most of the knowledge and techniques learned in the course, explain their approach and the steps taken, and analyze the results

in detail. The project is done as a team of two students. Each student is evaluated individually based on their contribution to the course project. The survey report and class presentation is done individually.

13. Assessment Instruments:

Assessment	Course Learning Outcomes
Homework	O1–O7
Class presentation	O9
Survey report	O1-O7 (depends on topic they select)
Research project	O8,O10
Final Exam	O1–O7

14. Contribution of Course to Program Outcomes:

MSCOE Program Outcomes	Emphasis in this course	Course Learning Outcomes
1. Perform research emphasizing creativity, independent learning, and scientific methods in a chosen area of computer engineering	○	O1-O8
2. Apply advanced mathematics and engineering knowledge in identifying, formulating and solving engineering problems	◑	O1-07
3. Select and use techniques, skills and modern tools necessary for research or professional practice	●	O1-O7
4. Communicate effectively	◑	O8
5. Recognize the need for and engage in life-long learning	◑	O8
6. Attend to professional and ethical responsibilities	○	O9

Emphasis: ● High; ◑Medium; ○ Low; Blank – Nothing Specific Expect

15. Letter Grade Policy:

Letter Grade	Total Score (T)
A	T >= 93
A-	89 <= T < 93
B+	84 <= T < 89
B	80 <= T < 84
B-	75 <= T < 80
C+	70 <= T < 75
C	66 <= T < 70
F	T < 66

It is considered an academic integrity violation to represent the output of a generative artificial intelligence tool as your own work.