



NATIONAL SCIENCE FOUNDATION  
2415 EISENHOWER AVENUE  
ALEXANDRIA, VIRGINIA 22314

**NSF 22-023**

## Dear Colleague Letter: Mathematical and Scientific Foundations of Deep Learning and Related Areas (MoDL+)

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December 6, 2021

Dear Colleague:

This Dear Colleague Letter (DCL) is to encourage the submission of proposals from interdisciplinary teams comprised of computer scientists, electrical engineers, mathematicians and statisticians, and social, behavioral, and economic scientists to address the most challenging theoretical and foundational questions in machine learning.

The National Science Foundation (NSF) Directorates for Computer and Information Science and Engineering (CISE), Engineering (ENG), Mathematical and Physical Sciences (MPS), and Social, Behavioral and Economic Sciences (SBE) promote interdisciplinary research in Mathematical and Scientific Foundations of Deep Learning and related areas (MoDL+). Deep learning and other related modern machine learning technologies have met with impressive empirical success, fueling fundamental scientific discoveries, and transforming numerous application domains of artificial intelligence. The incomplete theoretical understanding of the field, however, impedes the use of machine learning techniques by a wider range of participants. Confronting this incomplete understanding of the mechanisms underlying the successes and failures of machine learning is essential to overcoming its limitations and expanding its applicability.

### **PROPOSAL PREPARATION AND SUBMISSION**

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Proposals in response to this DCL should be submitted to appropriate existing NSF programs in one of the participating divisions; see below for the list of these. A proposal must meet the requirements and deadlines of the program to which it is submitted, but should include the prefix "MoDL: " in the proposal title after any program specific title requirements. Primary and secondary units of consideration on the cover sheet should indicate which programs from the participating divisions are most relevant.

PI teams must bring together appropriate expertise in two or more disciplines: computer

science; electrical engineering; mathematics/statistics; and social, behavioral, and economic sciences. Each project must clearly demonstrate substantial collaborative contributions of interest to the respective communities.

A wide range of scientific themes on theoretical foundations of deep learning and related areas of machine learning may be addressed in these proposals. Likely topics include, but are not limited to: geometric, topological, Bayesian, and game-theoretic formulations; analysis approaches exploiting optimal transport theory, optimization theory, approximation theory, information theory, dynamical systems, partial differential equations, and mean field theory; application-inspired viewpoints exploring efficient training with small data sets, adversarial learning, reinforcement learning, and closing the decision-action loop; foundational work on understanding success metrics, privacy safeguards, causal inference, algorithmic fairness, uncertainty quantification, interpretability, and reproducibility.

PIs from underrepresented groups and a broad range of institutions, including Minority-Serving Institutions and non-R1 institutions as defined in the [Carnegie Classification of Institutions of Higher Education](#), are especially encouraged to apply.

## **PARTICIPATING DIVISIONS AND CONTACTS**

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Questions concerning this Dear Colleague Letter should be directed to the e-mail alias: [modl@nsf.gov](mailto:modl@nsf.gov).

Sincerely,

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Directorate for Mathematical and Physical Sciences (MPS)

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