

FY2024-2026 EDUCATIONAL SKILLS REQUIREMENTS (ESRs)
Naval Mechanical Engineering
Subspecialty Code 560XP
Curriculum 570

1. Curriculum Number: 570
2. Curriculum taught at NPS.
3. Curriculum Length in months: 24 months
4. APC Required: 323
5. Community Managers have agreed to allow billets to be coded for Naval Mechanical Engineering 570 and officers to be educated for this curriculum.

<u>Designator</u>	<u>Officer Community Manager</u>
a. 1110	Surface
b. 1120	Submarine
c. 1440	Engineering Duty

6. The officer must understand the fundamental concepts and be familiar with the basic functional areas of Naval Mechanical Engineering within the Department of the Navy (DON) and the DoD including:

ESR-1: THERMODYNAMICS: Fundamentals of thermodynamics with applications to all marine engineering power cycles as well as propulsion and auxiliary system cycle analysis and design. Include hands-on laboratory experience.

Required Course #	Description	Alternate Course
ME2101	Thermodynamics (4-1)	Undergraduate
ME3240	Marine Power and Propulsion (4-2)	

ESR-2: FLUID MECHANICS: Compressible and incompressible flow, both viscous and inviscid, with emphasis on propellers, cavitation, and design of naval engineering systems (e.g., fluid machinery, pumps, turbo machinery). Include hands-on laboratory experience.

Required Course #	Description	Alternate Course
ME2101	Thermodynamics (4-1)	Undergraduate
ME2201	Introduction to Fluid Dynamics (3-2)	Undergraduate
ME3240	Marine Power and Propulsion (4-2)	

Enclosure (3)

Enclosure (3)

ESR-3: DYNAMICS AND CONTROL SYSTEMS:

Kinematics and dynamics of particle, rigid-body and multi-body mechanical systems. Modeling and simulation of engineering systems with mechanical, electrical and hydraulic components. Theory and practice of control systems engineering, including analysis and design of feedback systems. Use of linear systems concepts for modeling dynamic systems, designing feedback control and assessing system performance with applications to the design of feedback for naval component, process, platform, and weapon systems. Include hands-on laboratory experience.

Required Course #	Description	Alternate Course
ME2502	Dynamics (4-1)	Undergraduate
ME2801	Introduction to Control Systems (3-2)	EC2300

ESR-4: STRUCTURAL MECHANICS: Statically determinant and indeterminate structural analysis, stress/strain analysis, buckling, and failure; with applications to marine structures, including surface ships and submarines.

Required Course #	Description	Alternate Course
ME2501	Statics (3-0)	Undergraduate
ME2601	Solid Mechanics I (3-2)	Undergraduate

ESR-5: MATERIALS SCIENCE AND ENGINEERING: Material microstructure-property correlations, their association with fabrication and processing steps and applicability of those concepts to engineering materials of Naval relevance. The materials selection process, design, production (including additive manufacturing approaches), characterization of properties and analysis of failure mechanisms, fatigue and including use cases. Include hands-on laboratory experience.

Required Course #	Description	Alternate Course
MS3001	Materials Science and Engineering I (3-2)	
MS3002	Materials Science and Engineering II (3-2)	

ESR-6: ENGINEERING MODELING AND ANALYSIS: Practical experience of structured programming languages and the use of integrated design tools for computational and symbolic manipulation. Exposure to finite element and finite difference tools and techniques, with application to the thermo-fluid and structural mechanics/dynamics areas, including experience with representative software packages. Include hands-on laboratory experience.

Required Course #	Description	Alternate Course
AE2440	Introduction to Scientific Programming (3-2)	ME3440
MA3232	Numerical Analysis (3-2)	ME3440

ESR-7: MATHEMATICS: A basic understanding of statistics, multivariable and vector calculus, matrix and linear algebra, differential equations, partial differential equations, and numerical methods and their applications in mechanical engineering fields of study.

Required Course #	Description	Alternate Course
MA1115	Multi-variable Calculus (4-0)	Undergraduate or MA1995 & MA1996
MA1116	Vector Calculus (4-0)	Undergraduate or MA1995 & MA1996
MA2043	Introduction to Linear and Matrix Algebra (4-0)	Undergraduate or MA1995 & MA1996
MA2121	Differential Equations (4-0)	Undergraduate or MA1995 & MA1996
MA3132	Partial Differential Equations (4-0)	
MA3232	Numerical Analysis (3-2)	

ESR-8: DESIGN/SYNTHESIS: Design synthesis, with emphasis on the design of mechanical subsystems and their integration into the ship system.

Required Course #	Description	Alternate Course(s)
TS3002	Principles of Ship Design and Case Studies (3-2)	
ME3711	Design of Machine Elements (4-1)	Undergraduate

ESR-9: ELECTRICAL ENGINEERING: Electromagnetic and circuit theories, DC circuits, steady-state AC circuits, methods of circuit analysis, including Laplace transforms. Exposure to the construction and operating characteristics of rotating machinery, static converters, and power distribution systems and multi-phased circuits.

Required Course #	Description	Alternate Course(s)
EO2102	Introduction to Circuit and Power System Analysis (4-2)	Undergraduate
		TS3000
		NU3009

ESR-10: NAVAL ARCHITECTURE: Fundamentals of naval architecture including the geometry, hydrostatics and hydrodynamics of monohull floating and submerged structures. Wave and skin friction analysis, power requirements of particular designs. Longitudinal and transverse stability of floating and submerged bodies, hull girder strength requirements. Introduction to sea keeping and survivability principles.

Required Course #	Description	Alternate Course
TS3001	Fundamental Principles in Naval Architecture (3-2)	Undergraduate

ESR-11: CYBER: Fundamentals of the underlying principles of cyber infrastructure and systems, inherent vulnerabilities and threats including Industrial Control Systems, and defensive security procedures. (* ESR required for 14XX designators only)

Required Course #	Description	Alternate Course
ME4751	Survivability (4-1)	

ESR-12: SPECIALIZATION: Each student will also acquire technical competence in two or more of the following specialization areas through additional graduate level courses and their associated prerequisites including practical laboratory application:

Specialization Track Options:

- Fluids, Thermodynamics, and Heat Transfer
- Autonomy and Control Systems
- Solids and Structures
- Materials Science
- Design/Total Ship Systems Engineering

Specialization Selection:

- Choose two of the five specialization tracks.
- At least eight total classes from the two specialization tracks.
- At least two courses from each track.
- At least three courses at the 4000 level.
- At least two of the 4000 level courses must be related to thesis area.
- Technical electives may count toward any track

For Track 1; Fluids, Thermodynamics, and Heat Transfer, the following courses may include but are not limited to those listed. These are to include material covering heat transfer, as well as naval applications within propulsion and auxiliary system cycle analysis and design.

Course #	Description
ME3201	Applied Fluid Mechanics (4-1)
ME3150	Heat Transfer (4-1)
ME3450	Computational Methods in Mechanical Engineering (3-2)
ME4225	Comp Fluids and Heat Transfer (3-2)
ME4502	Hypersonic
ME4220	Viscous Flow (4-0)
ME4101	Advanced Thermodynamics (4-0)

For Track 2; Autonomy and Control Systems, the following courses may include but are not limited to those listed. These are to include material covering navigation and control for single and network-centric systems, as well as design of intelligent systems for machinery monitoring and automation, and autonomous vehicle operations within a naval domain.

Course #	Description
ME3801	Dynamics and Control of Marine and Autonomous Vehicles I (3-2)
ME3720	Introduction to Unmanned Systems (3-2)
EC4310	Fundamentals of Robotics (3-2)
ME4821	Marine Navigation (3-2)
ME4811	Multivariable Control of Ship Systems (3-2)

For Track 3; Solids and Structures, the following courses may include but are not limited to those listed. These are to include material covering design optimization, fatigue, and shock and vibration response of marine structures, including surface ships and submarines.

Course #	Description
ME3521	Mechanical Vibration (3-2)
ME3611	Mechanics of Solids II (4-0)
ME3450	Computational Methods in Mechanical Engineering (3-2)
ME4613	Finite Element Methods (4-0)
ME4522	FEM in Structural Dynamics (4-0)
ME4731	Engineering Design Optimization (4-0)

For Track 4; Materials Science, the following courses may include but are not limited to those listed. These are to include courses in both welding and corrosion.

Course #	Description
MS3304	Corrosion and Marine Environment Degradation (3-2)
MS3606	Introduction to Welding and Joining Metallurgy (3-2)
MS3202	Properties, Performance & Failure of Engineering Material (3-2)
ME3780	Introduction to Micro Electro-Mechanical Systems Design (3-3)
MS4901	Additive Manufacturing
MS4312	Characterization of Materials (3-2)

For Track 5; Design/Total Ship Systems Engineering, the following courses are required. This track awards the 5602P subspecialty code:

Course #	Description	Alternate Course
TS3000	Electrical Power Engineering (3-2)	
TS3003	Naval Combat System Elements (3-2)	
TS4000	Naval Combat Systems Engineering (3-2)	
TS4001	Integration of Naval Engineering Systems (3-2)	
TS4002	Ship Design Integration (2-4)	
TS4003	Total Ship Systems Engineering (2-4)	

For technical electives, the following courses may include but are not limited to those listed.

Required Course #	Description
ME4824	Applications of Deep Learning for Military Systems (3-2)
ME4800	Machine Learning for Autonomous Operations (3-2)
ME4751	Survivability (4-1)
ME4700	Weapon engineering (3-2)
ME4902	Directed Study (4-0)

ESR-13: ADVANCED TOPICS: All students must take at least one graduate-level course that exposes them to cutting-edge technology with military application of Mechanical Engineering. Courses that satisfy this requirement do not need to be within the MAE Department, and are at the discretion of the Program Officer or SME. Topics can include, but are not limited to, Alternative Energy, Nano-scale machines (MEMS), Artificial Intelligence/Machine Learning, Design Optimization, Modeling and Simulation, Additive Manufacturing (3D printing), Quantum Computing, Electric Propulsion and Hypersonics. Include hands-on laboratory experience.

ESR-14: THESIS: The graduate will demonstrate the ability to conduct independent analysis in the area of Naval/Mechanical Engineering, and proficiency in presenting the results in writing and orally by means of a thesis and command-oriented briefing appropriate to this curriculum.

Required Course #	Description	Alternate Course
ME0810	Thesis Research (0-8)	
ME0810	Thesis Research (0-8)	
ME0810	Thesis Research (0-8)	
ME0810	Thesis Research (0-8)	
ME0810 *	* Up to two additional thesis blocks may be added. (Requires approval of MAE Chair)	
ME0810 *		

APPROVED:  7/9/24
Major Area Sponsor Representative, [DATE]
NAVSEA 05

APPROVED:  07Aug2024
Director, OPNAV N71 [DATE]