

**FY2019-2021 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.

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).

Required Course #	Description	Alternate Course
ME2201	Introduction to Fluid Dynamics (3-2)	Undergraduate

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.

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.

Required Course #	Description	Alternate Course
MS2201	Engineering Materials (3-2)	Undergraduate
MS3202	Failure Analysis and Prevention (3-2)	
MS3304 or MS3606	Corrosion and Marine Environment Degradation (3-2) OR Introduction to Welding and Joining Metallurgy	MS3606 or MS3304

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.

Required Course #	Description	Alternate Course
AE2440	Matlab (3-2)	ME3440
MA3232	Numerical Analysis (3-2)	ME3440
OR ME3440 can be substituted for both AE2440 and MA3232	Engineering Analysis (4-0)	

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
MA1116	Vector Calculus (4-0)	Undergraduate
MA2043	Introduction to Linear and Matrix Algebra (4-0)	Undergraduate
MA2121	Differential Equations (4-0)	Undergraduate
MA3132	Partial Differential Equations (4-0)	
MA3232	Numerical Analysis (3-2)	ME3440

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

Required Course #	Description	Alternate Course(s)
ME3711	Design of Machine Elements (4-1)	
ME3712	Capstone Design Project (1-6)	Undergraduate Design Project, TS4003

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
EO2701	Introduction to Cyber Systems (4-2)	Undergraduate, EC2700

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:

1. Fluids, Thermodynamics, and Heat Transfer
2. Autonomy and Control Systems
3. Solids and Structures
4. Material Science
5. Design/Total Ship Systems Engineering

For Track 1; Fluids, Thermodynamics, and Heat Transfer, the following courses are required. These are to include material covering heat transfer, as well as naval applications within propulsion and auxiliary system cycle analysis and design.

Required Course #	Description	Alternate Course
ME3201	Applied Fluid Mechanics (4-1)	
ME3150	Heat Transfer (4-1)	
ME3450	Computational Methods in Mechanical Engineering (3-2)	
ME4XXX	Specialization Elective	
ME4XXX	Specialization Elective	
ME4XXX	Specialization Elective	

For Track 2; Autonomy and Control Systems, the following courses are required. 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.

Required Course #	Description	Alternate Course
ME3801	Dynamics and Control of Marine and Autonomous Vehicles I (3-2)	
ME3720	Introduction to Unmanned Systems (3-2)	
ME4XXX	Specialization Elective	
ME4XXX	Specialization Elective	
ME4XXX	Specialization Elective	

For Track 3; Solids and Structures, the following courses are required. These are to include material covering design optimization, fatigue, and shock and vibration response of marine structures, including surface ships and submarines.

Required Course #	Description	Alternate Course
ME3521	Mechanical Vibration (3-2)	
ME3611	Mechanics of Solids II (4-0)	
ME3450	Computational Methods in Mechanical Engineering (3-2)	
ME4XXX	Specialization Elective	
ME4XXX	Specialization Elective	
ME4XXX	Specialization Elective	

For Track 4; Materials Science, the following courses are required. These are to include courses in both welding and corrosion.

Required Course #	Description	Alternate Course
MS3304	Corrosion and Marine Environment Degradation (3-2)	
MS3606	Introduction to Welding and Joining Metallurgy (3-2)	
MS4XXX	Specialization Elective	
MS4XXX	Specialization Elective	
MS4XXX	Specialization Elective	

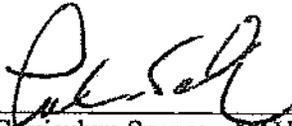
For Track 5; Design/Total Ship Systems Engineering, the following courses are required. This track awards the 5602P subspecialty code:

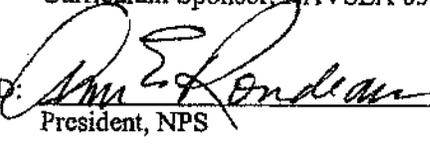
Required Course #	Description	Alternate Course
TS3000	Electrical Power Engineering (3-2)	
TS3002	Principles of Ship Design and Case Studies (3-2)	SE3100
TS3003	Naval Combat System Elements (3-2)	
TS4000	Naval Combat System Engineering (3-2)	SE4112
TS4001	Integration of Naval Engineering Systems (3-2)	
TS4002	Ship Design Integration (2-4)	
TS4003	Total Ship Systems Engineering (2-4)	
ME4XXX	Specialization Elective	

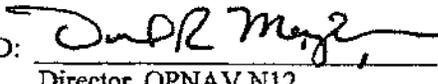
ESR-13: ADVANCED TOPICS: All students must take at least one graduate-level course that exposes them to cutting-edge technology with military application of Mechanical Engineering. Courses that satisfy this requirement do not need to be within the MAE Department, and are at the discretion of the Program 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.

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 *	* Up to two additional thesis blocks may be added. (Requires approval of MAE Chair)	
ME0810 *		

APPROVED:  12 APR 2019
 Curriculum Sponsor, NAVSEA 05 [DATE]

APPROVED:  4/17/19
 President, NPS [DATE]

APPROVED:  8 May 2019
 Director, OPNAV N12 [DATE]