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NAVAL RESERVE OFFICER TRAINING CORPS
NAVAL SHIPS SYSTEMS I (ENGINEERING)

Record of Changes

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This curriculum guide is written to standardize the NROTC course of instruction in Naval Ships Systems I, Naval Engineering. The lesson guides contain learning objectives that support the Professional Core Competencies (PCCs) Manual for Officer Accession Programs of April 2001. It is incumbent upon the instructor to ensure all identified objectives are adequately addressed.

Also included in this curriculum guide are case studies on ethical issues that support the critical leadership continuum throughout all four years of Naval Science instruction. These case studies are geared to engineering topics and will provide a basis for discussion of many situations that young officers will face early in their careers.

Instructors should promote critical thinking skills throughout this course of instruction and provide opportunities for students to demonstrate progression in both the cognitive and affective domains. Although this course focuses primarily on the cognitive and offers many opportunities for analysis, synthesis and evaluation, this curriculum can also be instructive in the affective domain as students practice valuing, organizing and internalizing aspects of Navy’s culture and methods. Instructors are encouraged to use their own past experiences to illustrate and enrich their classroom instruction.

This course is approved for implementation upon receipt. CNET P1550/4 (Rev. 4/96), NROTC Naval Ships Systems I (Naval Engineering), is hereby cancelled and superseded by this guide.

C. J. SPEIN
Director of Officer Development

Date 17 Jan 05
DEFINITION OF MEASUREMENT TERMS
(Used in describing desired Professional Core Competencies and supporting learning objectives)

I. **Know** - Recall facts, bring to mind and recognize the appropriate material.

Examples:
Know the objectives of damage control aboard ship.

Know the safety procedures used to provide the fullest measure of safe small boat operations.

II. **Comprehend** - Interpret principles and concepts and relate them to new situations.

Examples:
Comprehend the mission of the U.S. Navy and Marine Corps.

Comprehend the concept of internal forces (e.g., stress, strain, shear).

III. **Apply** - Utilize knowledge and comprehension of specific facts in new relationships with other facts, theories and principles.

Examples:
Apply correct plotting procedures when navigating in pilot waters.

Apply correct procedures to determine times of sunrise and sunset.

IV. **Demonstrate** - Show evidence of ability in performing a task.

Examples:
Demonstrate third class swimming skills and fundamental water survival skills.

Demonstrate the correct procedure used in radio-telephone communications.
The following professional competency objectives for this course are taken from the Professional Core Competency Manual for Officer Accession Programs promulgated in April 2001.

1. The student will comprehend the moral and ethical responsibilities of the military leader to the organization and society.

2. The student will comprehend the relationship of integrity, moral courage, and ethical behavior to authority, responsibility and accountability.

3. The student will comprehend the following personal qualities and be able to relate them to a leader's effectiveness: Loyalty, Honor, Integrity, and Courage (moral and physical).

4. The student will know the basic administrative responsibilities of an officer, including maintenance management and safety procedures.

5. The student will know the purpose of the Navy Maintenance Material Management (3-M) system and its PMS and MDCS subsystems, including the duties of the division officer and work center supervisor.

6. The student will comprehend the basic physical properties of opened and closed thermodynamic systems.
   a. The student will comprehend the various forms of energy, including potential, kinetic, thermal and mechanical, and the process of energy conversion.
   b. The student will comprehend the "laws of thermodynamics" and types of thermodynamic cycles.
   c. The student will comprehend the concepts of "work" and "efficiency" and determine levels of output and efficiency in theoretical situations.

7. The student will apply an understanding of the "laws of thermodynamics" and concepts of work, power and efficiency to various shipboard propulsion systems.
   a. The student will comprehend the basic operation, key components, and safety considerations within major propulsion systems, including the following:
(1) Gas turbine engines (single and split shaft), associated propulsion system, elements and secondary support systems.

(2) Conventional steam propulsion plants.
   (a) The student will apply the laws of thermodynamics to determine the changes in state/energy which water undergoes in the basic steam cycle and will comprehend the purpose of various components and their effect on these energy and state changes.
   (b) The student will know the purpose of routine feed water chemistry aboard ship.

(3) Nuclear steam propulsion plants.
   (a) The student will comprehend the basic fission process.
   (b) The student will comprehend the definition of the terms critical/sub-critical/super-critical relative to nuclear reactors and know what is meant by SCRAM.

(4) Internal combustion engines and associated propulsion systems.
   b. The student will know the features of various fuel oil systems and how they provide fuel to the thermodynamic cycle in each of the applicable systems above.

8. The student will comprehend the basic operation, principle components, and safety considerations related to key shipboard auxiliary systems and apply the concept of efficiency to such systems.
   a. The student will comprehend the theory of distilling plants.
   b. The student will comprehend the theory of operation of refrigeration and air conditioning systems.

9. The student will comprehend the theory of operation and key components of shipboard main propulsion power transmission from power source to propellers, including the effects of cavitation.

10. The student will comprehend and be able to apply the basic physical principles of electrical theory to shipboard power generation and distribution systems.
    a. The student will comprehend basic electrical theory,
including Ohm's law and its derivations; compare AC and DC electrical power and their uses and transmission.

b. The student will comprehend generator theory to determine frequency and voltage in an AC generator and comprehend the fundamentals of generator construction and control mechanisms, including prime movers and power ratings.

c. The student will comprehend the functions of the various elements in electrical distribution systems.

d. The student will comprehend the following with respect to shipboard electrical power distribution systems:

(1) Parameters that must be matched in paralleling generators.

(2) Measures to counter ship's magnetic field.

(3) Identification of vital and non-vital systems.

(4) Functions of the main switchboard.

(5) Difference between ship's service and emergency power distribution systems.

(6) Casualty power system.

11. The students will know the factors and criteria of ship design for seaworthiness, structural integrity and operational employment.

a. The student will know the design priorities used in construction of various warship types.

b. The student will comprehend the factors involved in machinery plant layout and design.

c. The student will know basic ship hull and structural component nomenclature.

d. The student will know the effects of stress, strain, and shear forces on hull design and know considerations involved in selection of materials for ship construction and the basics of structural design.

e. The student will comprehend how ship stability and stability redundancy are designed into a ship before construction, including allowance for future modifications.

f. The student will comprehend the factors involved in ship stability and be able to apply them in determination of
stability conditions.

(1) The student will comprehend hydrostatics, buoyancy, and Archimedes' principle.

(2) The student will comprehend static equilibrium and the relationship of center of gravity and buoyancy to righting arms and stability.

(a) The student will comprehend positive, neutral and negative stability conditions.

(b) The student will comprehend the effect of movements of the centers of buoyancy and gravity on stability.

(c) The student will know the use of stability curves/nomograms.

(d) The student will know the effect of free communication and free surface on stability characteristics.

12. The student will comprehend the basic principles of fluid dynamics and be able to apply them in shipboard situations.

a. The student will know Bernoulli's principle, kinetic versus potential energy in terms of fluid flow and the concept of pressure "head."

b. The student will comprehend Pascal's principle and basic hydraulics.

c. The student will know the definition of boundary layers.

13. The student will know the basics of shipboard safety and comprehend the reasons for extraordinary attention to safety and preparedness.

a. The student will know Navy safety programs and precautions, including ordnance, electrical, workplace, NAVOSH and environmental programs.

b. The student will know the requirements for shipboard damage control training and preparedness.

(1) The student will know how shipboard watertight integrity is obtained through installed shipboard features to increase material conditions of readiness.

(2) The student will know the procedures, objectives
and priorities in combating progressive deterioration from fire and underwater hull damage.

(a) The student will know classes of fire and agents, equipments, and procedures used to extinguish them.

(b) The student will know the use of equipment, materials and procedures for countering progressive flooding and structural deterioration.

(c) The student will know the procedures for donning and doffing and know the proper operation of oxygen breathing apparatus (OBA)/ self-contained breathing apparatus (SCBA).
# NAVAL RESERVE OFFICER TRAINING CORPS
## NAVAL SHIPS SYSTEMS I (ENGINEERING)

### LESSON TOPICS

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<td>Damage Control Systems and Equipment</td>
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<td>Tagouts and Gundecking Case Study</td>
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Total Hours 35
I. Videos

A. The following videos are part of the official curriculum and have previously been distributed to each unit:

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<tr>
<td>25748</td>
<td>Trial by Fire</td>
<td>26 min</td>
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<tr>
<td>806381 (Formerly 800588)</td>
<td>Fire on the Flight Deck</td>
<td>26 min</td>
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<tr>
<td>804635 (Formerly 804632)</td>
<td>Beating the Odds: The USS Samuel B. Roberts Fights for Life</td>
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B. The above videos should be controlled and serialized as part of the unit’s standing educational materials to ensure they are available for future courses of instruction. It is the responsibility of the unit to keep track of the location of the videos and to maintain them in good working condition. Replacements for damaged videos may be ordered from the NETPDTC Regional Visual Information Center by contacting Mr. Ron Burk at ronald.burk@navy.mil or (850) 452-1001, ext 2020.

C. The following films were previously a part of the Engineering curriculum, but replacement copies are no longer available. However, units may still have copies on hand that instructors may wish to include in their classroom instruction.

1. "Damage Control - Elements of Stability on Ships" (#23552), 37 min

2. "Damage Control - Loose Water in Stability in Intact Spaces" (#23557), 13 min

3. "Damage Control - Loose Water in Stability in Spaces Open to the Sea" (23558), 13 min

D. Other videos may be obtained from university or community libraries, online vendors, online in public domain areas (without cost), or purchased by the unit through commercial vendors. (NOTE: When purchasing videos, units should follow the copyright laws that
allow video usage for educational purposes/classroom use only.)

E. Instructors should be aware that commercial videos provided by NSTC or purchased by the unit are for use in an academic setting only. They are not to be reproduced, sold, copied, or shown in their entirety. Academic privileges allow instructors to utilize portions of videos, books, articles available to the public, and other media in academia to teach and educate. Using or distributing these videos in any fashion other than outlined here and in the lesson plans may constitute copyright infringements. Many short video clips from commercial movies provide the instructors contemporary, intriguing material to provide the students with examples of the ethical issues they are trying to teach. Use these segments appropriately. Seek official legal advice for any use not mentioned in this guide. Additional guidance may be found in SECNAVINST 5870.4.

F. Most universities have video libraries or audiovisual organizations that can provide current, topical films to units at no cost. These universities may also have additional funding or arrangements to purchase video rights and rental for use in the classroom environment. Consult with your university's film librarian to locate additional films to support lesson plans.

G. A wide variety of Department of Defense (DOD) materials is available through the Defense Automated Visual Information System/Defense Instructional Technology Information System (DAVIS/DITIS) website at: http://dodimagery.afis.osd.mil. This site contains listings and descriptions of thousands of audiovisual productions/ videotapes and interactive multimedia instructional products used by DOD. The NETPDTC Norfolk Regional Electronic Media Center may also be able to provide desired multimedia resources, by contacting Mr. Ron Burk at ronald.burk@navy.mil or (850) 452-1001, ext. 2020.

II. Internet Resources. All personnel must exercise caution in using material downloaded from the Internet. Access to works on the Internet does not automatically mean that these can be reproduced and reused without permission or royalty payment. Before using any materials downloaded from the Internet for use in training, you must determine what, if any, copyright restrictions might apply. A good rule of thumb would be to presume that any information on the Internet is copyrighted, and that you should not use it without obtaining permission from the copyright holder. SECNAVINST 5870.4 provides specific guidelines that should be addressed in the copyright permission request letter.
III. Instructional Devices
   A. Whiteboard/chalkboard
   B. Computer/projection system with PowerPoint slides or overhead projector with instructor-prepared transparencies
   C. Videocassette player with monitor/projection system

IV. Propulsion Plant Tours. Most universities and local communities have power generation plants that will provide tours that can be valuable teaching aids. Instructors are encouraged to take advantage of this opportunity.
NAVAL RESERVE OFFICER TRAINING CORPS
NAVAL SHIPS SYSTEMS I (ENGINEERING)

BIBLIOGRAPHY

I. Texts (1 per student/1 per instructor)


Kennedy, J. A., LT, USN, and R. A. Koonce, LT, USN. *Safety for the Division Officer* (SAUF 32621).

II. Instructor References (1 per instructor)


TITLE: Principles of Measurement

I. Learning Objective:

A. The student will comprehend the measurement of temperature and pressure to include:
   1. Units of measurement
   2. Measurement devices

II. References and Texts

A. Instructor references
   1. Introduction to Naval Engineering, Appendix A, pp. 511-516
   2. Principles of Naval Engineering, Chapter 7, pp. 7-1 through 7-18

B. Student texts
   1. Introduction to Naval Engineering, Appendix A, pp. 511-516
   2. Principles of Naval Engineering, Chapter 7, pp. 7-1 through 7-18

III. Suggested Methods/Instructional Aids

A. Lecture enhanced with computer presentation and whiteboard/chalkboard

B. Study Assignments

IV. Presentation

A. Discuss the purpose of measuring devices and why they are essential to proper operation of propulsion plants.

B. Discuss the measurement of temperature to include the following scales and conversions:
   1. Fahrenheit (F)
   2. Celsius (C)
   3. Kelvin (K)
4. Rankine (R)
   \[ F = 1.8 \, C + 32 \]
   \[ C = \frac{F - 32}{1.8} \]
   \[ K = C + 273.15 \]
   \[ R = F + 459.67 \]

C. Discuss the principle of operation of the following temperature measuring devices:

1. Expansion thermometers
   a. Liquid in glass
   b. Bimetallic
   c. Filled system/distant reading

2. Pyrometers
   a. Thermocouple
   b. Resistance
   c. Radiation and optical pyrometers

D. Discuss the measurement of pressure to include the following:

1. Definition of pressure (force per unit area)

2. Units of measurement
   a. PSI
   b. Inches Hg or inches H₂O

3. Relationship between:
   a. Gage pressure (PSIG)
   b. Absolute pressure (PSIA)
   c. Vacuum pressure (PSIV) or (in Hg)
   d. Atmospheric pressure
   e. Barometric pressure

E. Discuss the principles of operation of the following
pressure measuring devices:
1. Manometers
2. Bourdon tube
3. Bellows gage

F. Discuss installation and calibration of pressure and temperature measuring devices.

G. Perform the following sample problems:

Additional equations:

Absolute Pressure = Atmospheric Pressure + Gage Pressure

Vacuum = Atmospheric Pressure - Absolute Pressure

1. Convert the following temperatures to degrees Fahrenheit:

100 C    F = (1.8)(100) + 32    F = 212
0 C       F = (1.8)(0) + 32     F = 32
100 K     F = (1.8)(100-273.15) + 32  F = -278.67
0 K       F = (1.8)(0-273.15) + 32  F = -459.67
100 R     F = 100 - 459.67         F = -359.67
0 R       F = 0 - 459.67          F = -459.67

2. Determine the absolute pressure for the following:
   (assume sea level conditions)
   a. 100 PSIG

   PSIA = 14.7 PSI + 100 PSIG = 114.7 PSIA

   b. 10 PSIV

   PSIA = 14.7 PSI - 10 PSIV = 4.7 PSIA
I. Learning Objectives

A. The student will comprehend the various forms of energy, including potential/kinetic, thermal and mechanical and the process of energy conversion.

B. The student will comprehend the heat transfer processes of conduction, convection and radiation.

C. The student will comprehend the principles of operation of various heat exchangers.

D. The student will know the definition of boundary layers.

II. References and Texts

A. Instructor references

1. Introduction to Naval Engineering, Chapter 1, pp. 3-5 and Chapter 2, pp. 9-14, 16-28

2. Principles of Naval Engineering, Chapter 8, pp. 8-1 through 8-14

B. Student texts

1. Introduction to Naval Engineering, Chapter 1, pp. 3-5 and Chapter 2, pp. 9-14, 16-28

2. Principles of Naval Engineering, Chapter 8, pp. 8-1 through 8-14

III. Suggested Methods/Instructional Aids

A. Lecture enhanced with computer presentation and whiteboard/chalkboard

B. Study Assignments

IV. Presentation

A. Discuss the thermodynamics and state why its study is necessary to understand basic engineering systems.

B. Define and discuss the following terms and perform basic computations as necessary.
1. Mechanical energy
   a. Potential energy \((PE=mg\cdot h)\)
   b. Kinetic energy \((KE=\frac{1}{2}mV^2)\)
   c. Work (energy in transition)

2. Thermal energy
   a. Internal potential energy
   b. Internal kinetic energy
   c. Heat (energy in transition)
   d. BTU as a unit of measurement

C. Describe the mechanisms of heat transfer.
   1. Conduction. Explain the terms and uses of the general energy equation (PNE pg 8-8):
      \[ Q = kTA \left(\frac{t_1-t_2}{L}\right) \]
   2. Radiation
   3. Convection (natural and forced)

D. Define the following terms:
   1. Saturation temperature/pressure
   2. Saturated liquid/vapor
   3. Subcooled liquid
   4. Superheated vapor
   5. Sensible heat
   6. Latent heat
   7. Latent heat of vaporization
   8. Latent heat of fusion

E. Discuss the following heat exchangers and describe their uses in propulsion plants
   1. Parallel flow
2. Counter flow
3. Cross flow
4. Single pass
5. Multi-Pass

F. Define boundary layer and discuss its effect on heat transfer.

G. Discuss other factors effecting heat transfer to include:
   1. Scale/Chemical deposits
   2. Soot/Dirt buildup
TITeL: Thermodynamics: First and Second Laws of Thermodynamics

I. Learning Objectives

A. The student will comprehend the first law of thermodynamics and types of thermodynamic cycles.

B. The student will comprehend the basic principles of open and closed thermodynamic systems.

C. The student will comprehend thermodynamic processes to include non-flow and steady flow, and state change processes.

D. The student will comprehend the second law of thermodynamics and the concepts of entropy and reversibility.

E. The student will comprehend the concepts of "work" and "efficiency" and be able to apply these concepts to determine levels of output and efficiency in theoretical situations.

II. References and Texts

A. Instructor references

1. Introduction to Naval Engineering, Chapter 2, pp. 14-16, 28-38

2. Principles of Naval Engineering, Chapter 8, pp. 8-14 through 8-32

B. Student texts

1. Introduction to Naval Engineering, Chapter 2, pp. 14-16, 28-38

2. Principles of Naval Engineering, Chapter 8, pp. 8-14 through 8-32

III. Suggested Methods/Instructional Aids

A. Lecture enhanced with computer presentation and whiteboard/chalkboard

B. Study Assignments

IV. Presentation
A. Discuss the first law of thermodynamics to include:
   1. The principle of conservation of energy
   2. The general energy equation:
      \[ \text{Energy in} = \text{Energy out} \]
      or
      \[ U_2 - U_1 = Q - W \] (define all terms)

B. Explain and give examples of a thermodynamic system.

C. Discuss the five basic elements to all cycles.
   1. Working substance
   2. Engine (heated or unheated)
   3. Heat source
   4. Heat receiver
   5. Pump

D. Describe the differences between open and closed thermodynamic cycles.

E. Illustrate and apply the general energy equation (with computations) for non-flow processes (PNE pp. 8-18).

F. Describe and give examples of a steady flow process. Include in the discussion a definition of:
   1. Enthalpy \( H = U + PV \)
   2. Flow work

G. Discuss isobaric, isenthalpic, isothermal, and adiabatic state changes and where they may occur in the propulsion plant.

H. Discuss the second law of thermodynamics to include the concepts of reversibility and entropy.

I. Discuss the Carnot principle to include the following:
   1. The Carnot cycle being fully reversible
   2. Carnot thermal efficiency and its implications
   3. Performance of a sample calculation
NAVAL RESERVE OFFICER TRAINING CORPS
NAVAL SHIPS SYSTEMS I (ENGINEERING)

LESSON GUIDE: 4  HOURS: 1

TITLE: Pumps, Valves, and Fans

I. Learning Objectives
   A. The student will comprehend the basic construction and application of valves used in the propulsion plant.
   B. The student will comprehend the various methods of valve operation.
   C. The student will comprehend the operation and application of the different pumps found in the propulsion plant.
   D. The student will know Bernoulli's principle, kinetic versus potential energy (in terms of fluid flow), and the concept of pressure.
   E. The student will be familiar with the operation and application of centrifugal and axial fans.

II. References and Texts
   A. Instructor references
      1. Introduction to Naval Engineering, Chapter 28, pp. 477-501
      2. Principles of Naval Engineering, Chapter 18, pp. 18-10 through 18-20; Chapter 19, pp. 19-1 through 19-19
   B. Student texts
      1. Introduction to Naval Engineering, Chapter 28, pp. 477-501
      2. Principles of Naval Engineering, Chapter 18, pp. 8-10 through 18-20; Chapter 19, pp. 19-1 through 19-19

III. Suggested Methods/Instructional Aids
   A. Lecture enhanced with computer presentation and whiteboard/chalkboard

IV. Study Assignments

IV. Presentation
A. Describe the following valve components:
   1. Valve body
   2. Disc
   3. Seat
   4. Bonnet
   5. Packing
   6. Packing gland/nut
   7. Stem
   8. Wheel/Operating mechanism

B. Discuss the uses and operation of the following valves:
   1. Globe
   2. Gate
   3. Butterfly
   4. Check
   5. Relief

C. Discuss the following types of valve operating devices and where they are used:
   1. Manual
   2. Hydraulic
   3. Motor (electric and air operated)
   4. Solenoid

D. Describe the following pump components:
   1. Drive type (steam/electric/gear)
   2. Pump shaft
   3. Impeller
   4. Piston
   5. Casing
E. Discuss the following pump terms:

1. Volumetric flow rate
2. Pressure head and relationship to kinetic and potential energy (include Bernoulli's principle)
3. Net positive suction head (NPSH)
4. Pump flows and curves

F. Discuss the operation and application of the following pumps:

1. Positive displacement
2. Non-positive displacement
   a. Centrifugal
   b. Propeller
3. Jet pumps (eductors, ejectors)

G. Discuss what happens to volumetric flow rate and pressure head for the following pump combinations:

1. A single positive displacement pump
2. A single centrifugal pump
3. Centrifugal pumps in parallel
4. Centrifugal pumps in series
5. Multistaged centrifugal pumps

H. Discuss the operation and application of the following fans:

1. Axial
2. Centrifugal
NAVAL RESERVE OFFICER TRAINING CORPS
NAVAL SHIPS SYSTEMS I (ENGINEERING)

LESSON GUIDE: 5                        HOURS: 1

TITLE: Main Steam Cycle

I. Learning Objectives

A. The student will comprehend the application of the laws of thermodynamics to determine the changes in state/energy which water undergoes in the basic steam cycle.

B. The student will comprehend the purpose and safety issues of the various components and their effect on these energy and state changes.

C. The student will comprehend the four phases of the basic steam cycle and know the components found in each.

D. The student will comprehend the factors involved in machinery plant layout and design.

II. References and Texts

A. Instructor references

1. Introduction to Naval Engineering, Chapter 1, pp. 6-7; Chapter 3, pp. 41-51; and Chapter 10, pp. 175-179

2. Principles of Naval Engineering, Chapter 9, pp. 9-1 through 9-12

B. Student texts

1. Introduction to Naval Engineering, Chapter 1, pp. 6-7; Chapter 3, pp. 41-51; and Chapter 10, pp. 175-179

2. Principles of Naval Engineering, Chapter 9, pp. 9-1 through 9-12

III. Suggested Methods/Instructional Aids

A. Lecture enhanced with computer presentation and whiteboard/chalkboard

B. Study Assignments

IV. Presentation
A. Draw a block diagram of the steam cycle to include:
   1. Boiler
   2. Turbines (HP/LP)
   3. Condenser
   4. Main condensate pump (MCP)
   5. Main air ejector condenser
   6. Deaerating feed tank (DFT)
   7. Main feed booster pump (MFBP)
   8. Main feed pump (MFP)
   9. Economizer

B. Identify the four phases of the steam cycle to include the components found in each. Include in your discussion the safety considerations when operating these components.
   1. Generation: Boiler
   2. Expansion: Turbines
   3. Condensation: Condenser, MCP, air ejector condenser, DFT
   4. Feed: DFT, MFBP, MFP, economizer

C. Explain the generation phase to include:
   1. Transformation of chemical to thermal energy
   2. Pressure: Temperature relationships for both steam drum and superheater (include phase change)
   3. Reason for superheater
      a. Increase thermal efficiency
      b. Reduction of corrosion
      c. Reduction of erosion
   4. Desuperheated steam production and pressure temperature relationship

D. Explain the expansion phase to include:
1. Transformations of thermal energy to mechanical kinetic energy (at nozzles) to mechanical work (at blades)

2. General differences between HP and LP turbines

3. Pressure-temperature relationships throughout turbines

E. Explain the condensation phase to include:
   1. Reason for condensing steam to water
   2. Reason for vacuum
      a. More work out of turbines (higher efficiency)
      b. Ease of steam recovery
      c. Ease in conversion to water
   3. Pressure-temperature relationships across condenser

F. Explain the feed phase to include:
   1. Pressure-temperature relationships across each component
   2. Overall purposes for the feed phase
      a. Preheat
      b. Store
      c. Deaerate
      d. Increase pressure to deliver feedwater to the steam drum

G. Discuss the factors involved in machinery plant layout and design.
   1. Midships location of engine rooms and machinery rooms
   2. Functional relationships between components
   3. Use of multiple levels or decks
   4. Component relationship to centerline (stability)
   5. Ease of maintenance
6. Damage control (prevent spread of fires and flooding)
I. Learning Objectives

A. The student will comprehend the purpose of the main condensate system.

B. The student will comprehend the purpose, principles of operation and key components of the main condensate system.

C. The student will comprehend the thermodynamic aspects associated with the main condensate system to include condensate depression.

D. The student will comprehend the purpose, principles of operation and key components of the main feed system.

E. The student will comprehend the purpose of automatic boiler control systems.

F. The student will know the purpose of routine water chemistry aboard ship.

II. References and Texts

A. Instructor references

1. Introduction to Naval Engineering, Chapter 9, pp. 165-174; and Chapter 10, pp. 175-192

2. Principles of Naval Engineering, Chapter 13, pp. 13-1 through 13-7

B. Student texts

1. Introduction to Naval Engineering, Chapter 9, pp. 165-174; and Chapter 10, pp. 175-192

2. Principles of Naval Engineering, Chapter 13, pp. 13-1 through 13-7

III. Suggested Methods/Instructional Aids

A. Lecture enhanced with computer presentation and whiteboard/chalkboard

B. Study Assignments
IV. Presentation

A. Discuss the purposes of the main condensate system.

B. Draw a block diagram of the main condensate system and discuss the purpose and function of the following components, including the temperature/pressure changes occurring in each and the reasons for the changes:

1. Main condenser
   a. Operates at a vacuum to lower the condensation temperature, which increases plant efficiency
   b. Prevents condensation of steam in the turbine
2. Hotwell: Stores condensate
3. Main circulating water system
   a. Main circulating water pump: Used for astern propulsion, stopped, and ahead 5-7 knots
   b. Scoop injection (speeds > 5-7 knots)
   c. Expansion joints
   d. Isolation valves
4. Main condensate pump
5. Air ejectors
6. Air ejector condenser

C. Describe condensate depression to include why it is necessary and the disadvantages of too much (i.e., lost efficiency).

D. Discuss the purpose of the main feed system: Deaerate, preheat, and transport water from the DFT to the boiler at a rate to maintain proper boiler level.

E. Draw a block diagram of the main feed system and discuss the purpose and function of the following components, including the temperature/pressure changes occurring in each and the reasons for the changes:

1. Deaerating feed tank (DFT)
   a. Preheats feedwater
   b. Deaerates feedwater
2. MFBP
   a. Relationship to DFT (NPSH maintained)
   b. Consequences of losing NPSH
3. MFP
4. Feedwater control valve
5. Economizer

F. Describe the purpose and principles of operation of the makeup/excess feed system.

G. Describe the purpose and principles of operation of the following automatic boiler control subsystems:
   1. Automatic combustion controls (ACC)
   2. Feedwater controls (FWC)
   3. Main feed pump differential pressure controls

H. Describe the modes of control of the above subsystems including:
   1. Local manual
   2. Remote manual
   3. Automatic
   4. Airlock system function

I. Discuss boiler water chemistry control
   1. Coordinated phosphate chemistry control system (addition of TSP and DSP)
   2. Prevention of scale buildup
   3. Purpose of blowdowns
      a. Lower PH/phosphate level
      b. Remove sludge or suspended solids
      c. Remove chloride ions (from seawater accident)
4. Inspection/Cleaning requirements
TITLE: Nuclear Power Fundamentals

I. Learning Objectives

A. The student will comprehend the fission process and the definitions of the terms critical, sub-critical, and super-critical.

B. The student will know what is meant by “SCRAM.”

C. The student will comprehend the basic operation, key components, and safety considerations of a nuclear propulsion plant.

D. The student will comprehend the advantages, disadvantages, and capabilities of the nuclear propulsion system.

II. References and Texts

A. Instructor references

1. Introduction to Naval Engineering, Chapter 7, pp. 89-114

2. Principles of Naval Engineering, Chapter 15, pp. 15-1 through 15-18

B. Student texts

1. Introduction to Naval Engineering, Chapter 7, pp. 89-114

2. Principles of Naval Engineering, Chapter 15, pp. 15-1 through 15-18

III. Suggested Methods/Instructional Aids

A. Lecture enhanced with computer presentation and whiteboard/chalkboard

B. Study Assignments

IV. Presentation

A. Discuss basic chemical symbol notation and define isotopes of an element (specifically uranium).

B. Discuss the basic fission equation and how fission
physically occurs.

1. Compare the mass of the reactants to the products and relate the change in mass to the binding energy using $E=mc^2$. Explain the forms in which this energy is released.

2. Define fission fragment, fast neutron, and slow (thermal) neutron.

C. Diagram a basic neutron life cycle. Include the following events: leakage (both fast and thermal), absorption (both fast and thermal), thermalization, capture without fission, and fission.

D. Discuss the following terms with respect to the fission chain reaction: critical, sub-critical, super-critical, and SCRAM.

E. Discuss the purpose and operation of the reactor core, pressure vessel, pressurizer, reactor coolant loops, steam generator, reactor coolant pump, and control rods.

F. Discuss the following types of radiation produced in a nuclear reactor and how we protect personnel with the use of shielding: Alpha particles, Beta particles, Gamma rays, and Neutrons (fast and thermal).

G. Discuss the similarities between conventional and nuclear propulsion plants.

H. Discuss the advantages/capabilities of nuclear propulsion plants. Include the following:

1. Nuclear power allowed the first truly submersible weapons platform.

2. A Nimitz-class CVN carries approximately twice as much jet fuel and aircraft weapons as a conventionally powered CV of the same size.

3. Refueling required only every 10-15 years. Allows operational flexibility.

I. Discuss the disadvantages of nuclear propulsion plants. Include the following:


2. Great weight of shielding materials.

3. Environmental concerns due to nature of fission process. Considerable potential for public
J. Discuss the safety considerations associated with a nuclear propulsion plant.

K. List the ship and submarine classes that have nuclear propulsion plants.
NAVAL RESERVE OFFICER TRAINING CORPS
NAVAL SHIPS SYSTEMS I (ENGINEERING)

LESSON GUIDE: 8
HOURS: 2

TITLE: Diesel Engines

I. Learning Objectives

A. The student will comprehend the basic operation, key components, and safety considerations of diesel engines and propulsion plants.

B. The student will comprehend the advantages, disadvantages, and capabilities of diesel engines in propulsion plants.

C. The student will apply correct procedures and the laws of thermodynamics to determine interrelationships of work, power, and efficiency of diesel propulsion plants.

D. The student will know the features of the diesel engine fuel oil system and how it provides fuel to the engine.

II. References and Texts

A. Instructor references

1. Introduction to Naval Engineering, Chapter 11, pp. 195-222
2. Principles of Naval Engineering, Chapter 17, pp. 17-1 through 17-44

B. Student texts

1. Introduction to Naval Engineering, Chapter 11, pp. 195-222
2. Principles of Naval Engineering, Chapter 17, pp. 17-1 through 17-44

III. Suggested Methods/Instructional Aids

A. Lecture enhanced with computer presentation and whiteboard/chalkboard

B. Study Assignments

IV. Presentation
A. Discuss the applications of diesel engines in the Navy to include:
   1. Shipboard emergency electrical power (EDGs)
   2. Ship's boats
   3. Amphibious landing craft
   4. Main propulsion (LST, MCM, MSO, LSD-41 class)

B. Explain the basic thermodynamic principles, including pressure/temperature relationships of a diesel cycle. (Diesel -- compression ignition, compresses air only.)

C. Discuss the diesel engine structure, including:
   1. Stationary parts
      a. Engine frame
      b. Cylinder block
      c. Crankcase
      d. Oil sump
      e. Cylinder assembly, liner and heads
   2. Moving parts
      a. Piston (crown and skirt)
      b. Piston rings (describe purpose)
      c. Piston pin
      d. Connecting rod
      e. Crankshaft and main bearings
      f. Flywheel
      g. Camshaft and cams
      h. Lifters, pushrods and rocker arms
      i. Intake and exhaust valves
      j. Injectors
      k. Accessory drive mechanism
D. Define the following concepts:
   1. Stroke
   2. Top dead center (TDC)
   3. Bottom dead center (BDC)

E. Discuss the basic operation of a four-stroke diesel engine including the processes which occur during each of the following strokes:
   1. Intake
   2. Compression
   3. Power
   4. Exhaust

F. Discuss the basic operation of a two-stroke diesel engine and how it differs from a four-stroke engine. Include the following:
   1. Intake
   2. Blower/Supercharger
   3. Scavenging (discuss port/valve/uniflow)

G. Compare the relative strengths and weaknesses of the two- and four-stroke engine

H. Discuss diesel engine auxiliary systems to include Fuel Oil System, Lube Oil System, Air System and Ignition Systems.

I. Discuss diesel engine cooling systems.

J. Discuss diesel engine propulsion drive mechanisms.
   1. Indirect drive
   2. Direct drive

K. Discuss safety precautions associated with internal combustion engines, including:
   1. Fuel flammability
   2. Noise
   3. During maintenance procedures
LESSON GUIDE: 9                            HOURS:  2

TITLE:  Gas Turbine Theory

I. Learning Objectives
   A. The student will comprehend the thermodynamic processes occurring in a gas turbine engine, including a discussion of the Brayton Cycle.
   B. The student will comprehend the basic operation, key components, and safety considerations of gas turbine engines (single and split shaft) and propulsion plants, including support systems.
   C. The student will apply correct procedures, using the laws of thermodynamics, to determine level of work, power and efficiency in gas turbine engines.

II. References and Texts
   A. Instructor references
      1. Introduction to Naval Engineering, Chapter 12, pp. 225-244
      2. Principles of Naval Engineering, Chapter 16, pp. 16-1 through 16-35
   B. Student texts
      1. Introduction to Naval Engineering, Chapter 12, pp. 225-244
      2. Principles of Naval Engineering, Chapter 16, pp. 16-1 through 16-35

III. Suggested Methods/Instructional Aids
   A. Lecture enhanced with computer presentation and whiteboard/chalkboard

IV. Presentation
   A. Discuss the use of the gas turbine engine in today's Navy.
      1. Aircraft engines
2. Marine engines
   a. Main propulsion
   b. Auxiliary applications

B. Discuss the advantages of a gas turbine plant as compared to a steam plant of comparable horsepower.
   1. Weight reduction of 70%
   2. Simplicity (fewer propulsion auxiliaries)
   3. Reduced manning due to automated propulsion plant control
   4. Quicker response time
   5. Faster acceleration/deceleration
   6. Modular replacement

C. Discuss the operating cycle (Brayton cycle) of the gas turbine engine to include a pressure-volume diagram and the open/unheated thermodynamic cycle. Compare to diesel engine (open/heated) and steam propulsion (closed/unheated).

D. Discuss the purpose, safety considerations, and operation of the basic components of all gas turbine engines in detail.
   1. Compressor
      a. Pressurize intake air
      b. Two basic types
         (1) Radial flow
         (2) Axial flow
         (3) Advantages and disadvantages of each
      c. Discuss compressor stall.
      d. Discuss division of the compressed air.
         (1) Primary air
         (2) Secondary air
         (3) Film cooling
2. Combustors
   a. Mix compressed air with injected fuel and burn mixture to produce hot combustion gases
   b. Discuss types of combustors.
      (1) Annular
      (2) Can
      (3) Can-annular

3. Turbines
   a. Use hot combustion gases to produce the necessary torque to drive the compressor, accessories, and the load (shaft) or output to a nozzle (jet engine).
   b. Discuss construction of a typical turbine.
      (1) Fixed blades (nozzles)
      (2) Moving blades
   c. Discuss turbine blade cooling.

4. Accessory drive assembly
   a. Provides the space for mounting and the motive force for driving the accessories required for the operation and control of the engine.
   b. Discuss the following accessory equipment attached at the assembly:
      (1) Fuel oil pump
      (2) Lube oil pump
      (3) Starter (pneumatic, electric, hydraulic)

E. Draw a block diagram of both the single shaft and split shaft gas turbine engine to include the following components:
   1. Starter
   2. Compressor
   3. Combustion chamber
4. Turbine (gas generator turbine on the split shaft engine)

5. Power turbine

6. Propulsion power coupling

**INSTRUCTOR NOTE:**

*Single shaft engines:* Primarily used for electric power because of constant speed, regardless of load in this type of machine.

*Split shaft engine:* More suitable for main propulsion applications due to the fact that the gas generator turbine and power turbine operate near their most efficient speeds throughout a range of load demands.

F. Discuss transmission of engine power, including the following methods:

1. Reduction gears

2. Thrust or jet propulsion

G. Discuss safety considerations regarding gas turbine propulsion plants.
NAVAL RESERVE OFFICER TRAINING CORPS  
NAVAL SHIPS SYSTEMS I (ENGINEERING)

LESSON GUIDE: 10  
HOURS: 2

TITLE: The Gas Turbine Propulsion Plant

I. Learning Objectives

A. The student will know the features of shipboard gas turbine plant arrangements, including main propulsion and auxiliary machinery configuration on the FFG-7, DD-963, and CG-47 class ships.

B. The student will know the features of the intake and exhaust duct systems in a typical gas turbine plant.

C. The student will know the propulsion plant lineups and control variations for the typical gas turbine plant.

II. References and Texts

A. Instructor reference: Introduction to Naval Engineering, Chapter 12, pp. 249-263

B. Student text: Introduction to Naval Engineering, Chapter 12, pp. 249-263

III. Suggested Methods/Instructional Aids

A. Lecture enhanced with computer presentation and whiteboard/chalkboard

B. Study Assignments

IV. Presentation

A. Discuss the general configuration of the various ship classes engineering plants, including:

1. Location of major engineering spaces

2. Two LM-2500 gas turbine engines per shaft

3. Opposing arrangement of gas turbine engines for opposite shafts

4. Location of 3 generator sets (GTG/SSDG)

B. Describe the gas turbine base enclosure assembly or module used aboard ship to include:

1. One enclosure per engine, main propulsion and
turbine generators, not accessible during normal operations

2. Shock mounted
   a. Absorbs abrupt movement of the ship
   b. Prevents engine noise from being transmitted to the hull

3. Thermally and acoustically insulated (can withstand 2000°F for 14 minutes)

4. Fire detection and extinguishing system
   a. Automatic engine shutdown
   b. Automatic activation of CO2/Halon 1301 extinguishing system
   c. Flame detectors/temperature sensors and manual push button

C. Describe the intake and exhaust systems to include:
   1. Inlet ducts
      a. Location to prevent ingestion of seawater
      b. Demisters/intake heaters/blow-in doors
      c. Silencers
      d. Foreign object damage screen -- mounted in inlet plenum
      e. Module cooling air
   2. Exhaust ducts
      a. Silencers
      b. Exhaust gas cooling
         (1) Eductor effect
         (2) Mixes with module cooling air

D. Indicate plant layout for discussion of the auxiliary and support machinery and relationships in the discussion of plant components, including:
   1. Purpose of the auxiliary
2. Reason for duplication of equipment

3. The prime mover or power source

4. Location on board a ship, including survivability and relationship with other auxiliaries
   a. Air conditioning units: Electrical
   b. Sewage treatment plant: Electrical pumps
   c. Fire pumps: Electrical
   d. Waste heat boilers: Steam for hotel services
   e. Evaporators: Electrical pumps
   f. Sea water pumps: Electrical
   g. HP/LP air compressors

E. Discuss the control and operation of the engineering plant aboard a DD-963 class ship.

1. Engineering control and surveillance system (ECSS)
   a. Automated electronic control and monitoring system for main propulsion turbines, generating sets, and most auxiliaries
   b. Monitoring and printout of major engineering parameters

2. Normal throttle and CPP control at bridge (SCC)
   a. Signal from bridge is routed through the propulsion and auxiliary control console (PACC) in the central control station, and then through the propulsion local control console (PLCC) in each main engineering room.
   b. Main engine throttle and CRP for each shaft may be controlled at any of the three stations.

F. Discuss various propulsion plant lineups.

G. Discuss the advantages, disadvantages and capabilities of gas turbine engines as main propulsion plants, including: readiness, fuel costs, maintenance, reliability, and personnel requirements.
TITLE: Power Train Components

I. Learning Objectives
   A. The student will comprehend the theory of operation and key components of shipboard main propulsion power transmission from power source to propellers.
   B. The student will comprehend the effects of cavitation.
   C. The student will apply correct procedures and comprehension of propeller design parameters to determine efficiency at different speeds.

II. References and Texts
   A. Instructor references
      1. Introduction to Naval Engineering, Chapter 8, pp. 143-164
      2. Principles of Naval Engineering, Chapter 5, pp. 5-1 through 5-20
   B. Student texts
      1. Introduction to Naval Engineering, Chapter 8, pp. 143-164
      2. Principles of Naval Engineering, Chapter 5, pp. 5-1 through 5-20

III. Suggested Methods/Instructional Aids
   A. Lecture enhanced with computer presentation and whiteboard/chalkboard
   B. Study Assignments

IV. Presentation
   A. Discuss the main reduction gears to include:
      1. Purpose
      2. Classification
         a. Double helical
b. Double reduction

c. Locked train

3. Construction

a. Reduction pinions and gears

b. Quill shaft

c. Second reduction gear (bull gear)

d. Kingsbury thrust bearing

e. Turning gear

f. Attached pumps

B. Briefly discuss power transmission through the shafting to include:

1. Thrust shaft

2. Line shaft

3. Stern tube shaft

4. Tail shaft

5. Torsionmeter(s)

6. Spring bearing

7. Stern tube bearing

8. Strut bearing

9. Couplings

10. Bulkhead stuffing

11. Stern tube stuffing

12. Fairwaters

13. Strut

14. Propeller

15. Syntron seal

C. Discuss the following concerning propellers.
1. Components: Blade and hub

2. Classification of screw propellers
   a. Fixed pitch
   b. Controllable pitch
   c. Right/Left hand

3. Cavitation and its implications

4. Discuss the basic components and operation of a controllable pitch propeller (CPP) system to include:
   a. Oil distribution box
   b. Valve rod
   c. Hub and blade assembly
   d. Hydraulic oil power module (HOPM)
   e. Attached CPP pump

5. Discuss the advantages of CPP systems.

6. Explain the significance of the following values:
   a. Shaft horsepower
   b. Effective horsepower
   c. Propulsive horsepower
   d. Slip ratio

7. Explain how propeller design parameters (such as pitch, size, location, and number of propellers) affect efficiency at different speeds.
LESSON GUIDE: 12  
HOURS: 1

TITLE: Fuel/Lube Oil Systems

I. Learning Objectives

A. The student will know the features of a standard ship board fuel oil system.

B. The student will know the features of a standard ship board lube oil system.

C. The student will know the standard safety considerations for shipboard fuel oil and lube oil systems.

II. References and Texts

A. Instructor references

1. Introduction to Naval Engineering, Chapter 6, pp. 81-84 and Chapter 8, pp. 149-154

2. Principles of Naval Engineering, Chapter 6, pp. 6-1 through 6-9; Chapter 9, pp. 9-19 through 9-21

B. Student texts

1. Introduction to Naval Engineering, Chapter 6, pp. 81-84 and Chapter 8, pp. 149-154

2. Principles of Naval Engineering, Chapter 6, pp. 6-1 through 6-9; Chapter 9, pp. 9-19 through 9-21

III. Suggested Methods/Instructional Aids

A. Lecture enhanced with computer presentation and whiteboard/chalkboard

B. Study Assignments

IV. Presentation

A. Using a block diagram, discuss a basic fuel oil system to include:

1. Storage tanks

2. Service tanks
a. 24-hour fuel supply
b. For immediate use

3. Contaminated oil settling tanks
   a. Contaminants pumped out to oily waste tank
   b. Good oil sent to service tanks

4. Fill and transfer system
5. Stripping system
6. Service system

B. Using a block diagram, discuss a basic main lube oil system to include:
   1. Storage tanks
   2. Settling tanks
   3. Cooler/heater
   4. Pumps
      a. Attached lube oil pump (ALOP)
      b. Standby lube oil pump (SLOP)
      c. Emergency lube oil pump (ELOP)

C. Discuss components common to both systems to include:
   1. Strainers
   2. Filters
   3. Coalescers
   4. Purifiers

D. Discuss safety precautions associated with fuel oil and lube oil systems.
   1. Flammable liquid at high pressure (Class "B" fire)
   2. Strainer enclosures and flange shielding
TITLE: Distilling Plants

I. Learning Objectives

A. The student will comprehend the theory of operation, principle components, basic layout, and safety considerations related to distilling plants.

B. The student will comprehend the energy transformations which occur in distilling plants.

C. The student will comprehend determination of output and efficiency in distilling plant systems.

II. References and Texts

A. Instructor references

1. Introduction to Naval Engineering, Chapter 14, pp. 283-292

2. Principles of Naval Engineering, Chapter 21, pp. 21-1 through 21-20

B. Student texts

1. Introduction to Naval Engineering, Chapter 14, pp. 283-292

2. Principles of Naval Engineering, Chapter 21, pp. 21-1 through 21-20

III. Suggested Methods/Instructional Aids

A. Lecture enhanced with computer presentation and whiteboard/chalkboard

B. Study Assignments

IV. Presentation

A. Discuss the uses of fresh water to include:

1. Drinking, cooking, showering, laundering, and cleaning

2. Steam plant makeup, fresh water washdown
3. Electronics cooling

B. Discuss the distillation process to include the following definitions:

1. Distillation
2. Evaporation
3. Vapor
4. Condensation
5. Distillate
6. Brine
7. Salinity
8. Feed

C. Describe in detail the basic operation, principle components, and basic layout of the flash type distilling unit to include:

1. Pumps
   a. Seawater/Feed
   b. Brine
   c. Distillate

2. Heat transfer devices
   a. Distillate cooler
   b. Second and first stage condensers
   c. Air ejector condenser

3. Air ejectors
4. Feed boxes
5. Flash chambers
6. Vapor separators (demisters)
7. Heat sources
   a. Air ejector steam (150 # auxiliary)
b. Auxiliary exhaust

8. Water flow
   a. Seawater
   b. Brine
   c. Distillate

9. Steam flow
   a. 150 # auxiliary
   b. Auxiliary exhaust

10. Advantages of operating below atmospheric pressure (i.e., more efficient, negatively soluble salts)

D. Discuss the principles of operation of the reverse osmosis distilling plant (high purity output).

E. Discuss the dependency of feed and potable water on the proper operation of the distilling plant. Conservation methods:
   1. Navy showers
   2. Water hours
   3. Modified chow preparation and cleanup

F. Discuss the following safety considerations:
   1. Chemical addition to remove microorganisms (Bromine, Chlorine)
   2. Inability to remove volatile gases or liquids with a boiling point lower than water
   3. Geographic limits (contaminated seawater)
TITLE: Hydraulic Systems and Applications

I. Learning Objectives
   A. The student will comprehend the basic operation, principle components, and safety considerations related to hydraulic systems.
   B. The student will comprehend the method of determination of output given input and configuration of given hydraulic systems.
   C. The student will comprehend Pascal's principle and basic hydraulics theory.

II. References and Texts
   A. Instructor reference: Introduction to Naval Engineering, Chapter 15, pp. 293-306
   B. Student text: Introduction to Naval Engineering, Chapter 15, pp. 293-306

III. Suggested Methods/Instructional Aids
   A. Lecture enhanced with computer presentation and whiteboard/chalkboard
   B. Study Assignments

IV. Presentation
   A. Discuss shipboard systems that use hydraulic power.
      1. Steering gear
      2. Deck machinery: Anchor windless, winches, capstans
      3. Weapons systems: Gun mounts, launchers
      4. Other applications: Hydraulic presses, ramps, elevators
   B. Briefly discuss the physical properties of liquids.
      1. Shapelessness
2. Incompressibility
3. Transmission of force

C. Discuss Pascal's Law and work some sample problems using the law.

D. Draw a block diagram of a simple hydraulic system and describe the operation of the following components:
   1. Reservoir
   2. Pressure source: Hydraulic pump
   3. Pressure user: Hydraulic motor
   4. Piping systems
   5. Accumulator
   6. Hydraulic fluid (normally oil)

E. Discuss the principles of operation of the Waterbury pump with respect to its uses as:
   1. Hydraulic pump ("A" end)
   2. Hydraulic motor ("B" end)

F. Discuss the advantages of using oil as a hydraulic fluid.
   1. Non-corrosive
   2. Superb lubricant

G. Discuss the advantages and disadvantages of hydraulic systems.
   1. Advantages:
      a. Convenient method of power transmission
      b. Great flexibility
      c. Variable speed control
      d. Safety and reliability
   2. Disadvantages
      a. Need for positive confinement
      b. Fire hazard if leaks occur
c. Leaks in high pressure systems pose a safety hazard

d. Adequate oil filtration must be maintained

H. Discuss the operation of electrohydraulic steering gear to include the following components:

1. Ram unit
   a. Tiller
   b. Rudder posts
   c. Connecting links
   d. Crossheads
   e. Ram (B end)
   f. Hand pump

2. Power unit
   a. Electric motor
   b. Waterbury pump (A end)
   c. Transfer valves
   d. Remote steering unit
   e. Trick wheel

I. Discuss methods of steering control

1. Normal control from ship's bridge

2. Alternate control from after steering
   a. "Trick wheel"
   b. Hand pump
TITLE: Fundamental Electrical Theory

I. Learning Objectives

A. The student will comprehend basic electrical theory, including Ohm's law and its derivations.

B. The student will apply correct procedures and comprehension of generator theory to determine frequency and voltage in an AC generator.

C. The student will comprehend the fundamentals of generator construction and control mechanisms, including prime movers and power ratings.

D. The student will comprehend the fundamentals of electric motor theory, including construction, power rating, usages, and control mechanisms.

E. The student will compare the uses for AC and DC electric power and their transmission methods.

F. The student will comprehend electrical circuit schematic symbology, including the symbols for "wye" and "delta" connections.

II. Reference and Texts

A. Instructor references

1. Introduction to Naval Engineering, Chapter 16, pp. 307-318

2. Principles of Naval Engineering, Chapter 20, pp. 20-1 through 20-20

B. Student texts

1. Introduction to Naval Engineering, Chapter 16, pp. 307-318

2. Principles of Naval Engineering, Chapter 20, pp. 20-1 through 20-20

III. Suggested Methods/Instructional Aids

A. Lecture enhanced with computer presentation and whiteboard/chalkboard
B. Study Assignments

IV. Presentation

A. Discuss direct current (DC) theory, specifically:
   1. Electromotive force
   2. Current
   3. Relative motion
   4. Ohm's law and its applications
   5. Resistance
   6. Conductor
   7. Insulator

B. Discuss generation of DC voltage in a simple DC generator to include:
   1. Magnetic field
   2. Armature
   3. Relative motion
   4. Left hand generator rule
   5. Right hand motor rule

C. Discuss alternating current (AC) theory, specifically:
   1. Electromagnetic induction
   2. Method of single phase AC voltage generation:
      a. Frequency
      b. Amplitude
      c. Phase
   3. Method of three-phase AC voltage generation:
      a. Wye connections
      b. Delta connections
   4. Relationship between frequency of generated AC power and the speed of the rotating magnetic field
\[ f = \frac{(P)(\text{RPM})}{120} \]

where \( f \) = frequency (hertz)
\( p \) = number of generator poles

\( \text{RPM} \) = speed of the rotating magnetic field in revolutions per minute

D. Discuss the construction and methods of control for a revolving field AC generator, specifically:

1. Different types of prime movers
2. Rotors
   a. Slip rings
   b. Brushes
3. Stator
4. Field windings
5. Armature windings
6. Poles
7. DC power supply (generator voltage control)
8. Generator classification with respect to:
   a. Current type
   b. Number of phases
   c. Frequency
   d. Voltage
   e. Power rating

E. Discuss the basic operation and construction of a simple electric motor.

F. Discuss the reasons for the usage of AC power versus other sources for shipboard installations.

G. Discuss the production of voltage by chemical action (batteries).

H. Discuss the operation and construction of basic transformers.
NAVAL RESERVE OFFICER TRAINING CORPS
NAVAL SHIPS SYSTEMS I (ENGINEERING)

LESSON GUIDE:  16          HOURS:  1

TITLE:  Shipboard Electrical Distribution

I.  Learning Objectives

A.  The student will comprehend the principles of operation of a three-phase AC shipboard power distribution system.

B.  The student will comprehend the functions of the various elements of a ship's electrical distribution system.

C.  The student will comprehend the difference between ship's service and the emergency power distribution systems.

D.  The student will comprehend the function of the casualty power system.

E.  The student will identify vital and non-vital systems.

F.  The student will comprehend measures which may be employed to counter the ship's magnetic field.

G.  The student will comprehend the requirements for paralleling generators prior to placing an electrical load on them.

H.  The student will comprehend the function of the main switchboard.

II.  Reference and Texts

A.  Instructor references

1.  Introduction to Naval Engineering, Chapter 17, pp. 319-332

2.  Principles of Naval Engineering, Chapter 20, pp. 20-21 through 20-35

B.  Student texts

1.  Introduction to Naval Engineering, Chapter 17, pp. 319-322

2.  Principles of Naval Engineering, Chapter 20, pp. 20-21 through 20-35
III. Suggested Methods/Instructional Aids

A. Lecture enhanced with computer presentation and whiteboard/chalkboard

B. Study Assignments

IV. Presentation

A. Use a schematic of a basic shipboard electrical distribution system to illustrate a discussion of the following components:

1. SSTGs
2. EDGs
3. Main switchboards
4. Emergency switchboards
5. ABTs and MBTs
6. Casualty power connection points
7. Circuit breakers
8. Bus ties
9. Disconnects
10. Shore power connections

B. Discuss the functions of the following components:

1. Controllers
2. Switches
3. Fuses
4. Transformers
5. Relays

C. Discuss the advantages and disadvantages of an ungrounded electrical distribution system (e.g., increases equipment reliability; does not increase personnel safety).

D. Discuss the difference between vital and non-vital demands on a ship's available power generation capacity and give several examples of each:
1. Vital: Steering system, fire fighting pumps, main propulsion requirements, weapons systems

2. Non-vital: Galley requirements, lighting in berthing spaces, main deck receptacles

E. Differentiate between ship's service and emergency power distribution systems and relate them to the necessity of maintaining vital systems.

F. Discuss the parameters that must be met when paralleling generators, including:

1. Matching voltage and phase
2. Frequency of oncoming generator slightly higher than on line SSTG

G. Discuss the sequence of events that occur when normal electrical power is lost (INE Figure 17-4, pp. 324).

1. Actions of ABTs and emergency diesel generator
2. Re-energizing vital loads
3. Use of bus ties
4. Use of MBTs (as necessary)

H. Discuss the function of the casualty power system, when it is used, and the sequence of connecting this system to components of the ship's fixed power distribution systems.

I. Briefly discuss the reasons for the ship's degaussing system and when and how it is energized.
NAVAL RESERVE OFFICER TRAINING CORPS
NAVAL SHIPS SYSTEMS I (ENGINEERING)

LESSON GUIDE:  17             HOURS:  1

TITLE:  Compressed Air Systems

I.  Learning Objectives

   A.  The student will comprehend the principle components, basic operation, and safety considerations associated with shipboard air compressors and compressed air systems.

   B.  The student will apply correct procedures and comprehension of the principles of thermodynamics to determine output and efficiency of shipboard air compressors.

II.  Reference and Texts

   A.  Instructor references

      1.  Introduction to Naval Engineering, Chapter 18, pp. 333-340

      2.  Principles of Naval Engineering, Chapter 23, pp. 23-1 through 23-21

   B.  Student texts

      1.  Introduction to Naval Engineering, Chapter 18, pp. 333-340

      2.  Principles of Naval Engineering, Chapter 23, pp. 23-1 through 23-21

III. Suggested Methods/Instructional Aids

   A.  Lecture enhanced with computer presentation and whiteboard/chalkboard

   B.  Study Assignments

IV. Presentation

   A.  Differentiate between systems which require high pressure air and those needing medium or low pressure compressed air.

      1.  Automatic combustion controls

      2.  "Prairie" and "masker" systems
3. Torpedo charging
4. Diesel starting air
5. Gas turbine starting
6. Deballasting
7. Pneumatic tools
8. Weapons system requirements

B. Discuss the classification of air compressors to include:

1. Displacement type (Positive/non-positive)
2. Type of staging (Single stage/multistage)
3. Type of drive (Electric motor/internal combustion engine/turbine)
4. Operating pressures
   a. Low (0 - 150 PSI)
   b. Medium (151 - 1000 PSI)
   c. High (over 1000 PSI)
5. Output capacity (measured in ft$^3$/min, CFM)

C. Discuss compressed air system components, including compressor, lubricating system, cooling system, control system, unloading system, accumulators, and priority valve.

D. Briefly discuss the bleed air system as a major source of pressurized air aboard gas turbine ships.

E. Stress the potential dangers and required safety precautions relating to air compressor systems.

1. Oil vapor in compressor
2. Leaking coolers
3. Improper maintenance
   a. Working on pressurized components
   b. Using parts from lower pressure systems
LESSON GUIDE:  18
HOURS:  1

TITLE:  Refrigeration and Air Conditioning Plants

I. Learning Objectives

A. The student will comprehend the basic operation, principle components, and safety considerations related to refrigeration and air conditioning systems.

B. The student will apply correct procedures including comprehension of the thermodynamic principles involved to determine output and efficiency of refrigeration systems.

II. References and Texts

A. Instructor references

1. Introduction to Naval Engineering, Chapter 19, pp. 341-351
2. Principles of Naval Engineering, Chapter 22, pp. 22-1 through 22-17

B. Student texts

1. Introduction to Naval Engineering, Chapter 19, pp. 341-351
2. Principles of Naval Engineering, Chapter 22, pp. 22-1 through 22-17

III. Suggested Methods/Instructional Aids

A. Lecture enhanced with computer presentation and whiteboard/chalkboard

B. Study Assignments

IV. Presentation

A. Discuss the uses of refrigeration and air conditioning systems to include:

1. Cooling of stores and cargo
2. Cooling of electronic spaces and equipment
   a. CIC (computers and consoles)
b. Radio (communications gear)

c. Radars

3. Cooling of magazines
4. Air conditioning for crew comfort

B. Review the definitions of the following terms:

1. Specific heat
2. Sensible heat
3. Latent heat of fusion
4. Latent heat of vaporization
5. BTU
6. Refrigeration ton

C. Discuss the Brayton cycle and refrigerant state changes. Include a detailed explanation of pressure and temperature changes.

D. Describe the vapor-compression refrigeration cycle, including refrigerant, receiver, thermostatic expansion valve (TXV), evaporator, compressor, condenser, and refrigerant flow.

E. Discuss the principles of operation of the following types of air conditioning systems:

1. Refrigerant circulating system
2. Chilled water circulating system
3. Self-contained system

F. Discuss the safety precautions associated with refrigerant and air conditioning systems, including:

1. Phosgene gas hazard (created when refrigerant is exposed to high temperatures)
2. Handling procedures: Wear goggles and gloves to avoid eye irritation and frostbite
3. Asphyxiation hazard in non-ventilated spaces
4. Handling of compressed gas bottles
LESSON GUIDE: 19

HOURS: 1

TITLE: Engineering Documentation

I. Learning Objectives

A. The student will know the technical information sources available for ship’s force use.

B. The student will know the uses of the engineering operational sequencing system (EOSS) manuals.

C. The student will know the records, logs, and trend analyses used to document operating histories.

D. The student will know the purpose and basic instructions governing the equipment tagout system.

E. The student will know Navy safety programs and precautions, including ordnance, electrical, workplace, NAVOSH, and environmental programs.

II. References and Texts

A. Instructor references

1. Introduction to Naval Engineering, Chapter 29, pp. 502-510

2. Safety for the Division Officer

B. Student texts

1. Introduction to Naval Engineering, Chapter 29, pp. 502-510

2. Safety for the Division Officer

III. Suggested Methods/Instructional Aids

A. Lecture enhanced with computer presentation and whiteboard/chalkboard

B. Study Assignments

IV. Presentation

A. Discuss the purpose, scope, and location of ship’s technical information sources, including: NSTM, SIB, equipment technical manuals, and blueprints/drawings.
B. Discuss the engineering operational sequencing system.

C. Discuss the engineering department logs and records, and the need for trend analysis and the location of each.

1. Legal records
   a. Engineer’s Log
   b. Engineer’s Bell Book

2. Informational logs and records
   a. Fuel, Oil, and Water Report
   b. Boiler Water Treatment Log
   c. Engineer Officer’s Night Order Book
   d. Fuel Memorandum
   e. Draft Report
   f. D.C. Closure Log

3. Watch station operating logs
   a. Historical data to observe equipment operating trends
   b. Aid in identifying possible abnormalities

D. Discuss the equipment tagout system

1. Important to safety of personnel and equipment

2. Types of tags and their uses
   a. Danger
   b. Caution

3. Review the requirements for posting and removing tags
   a. Tagout log entries
   b. Signature requirements

E. Discuss the Safety for the Division Officer handbook. Ensure students read and complete discussion questions for Chapters 3 through 10 regarding ordnance safety, electrical safety, workplace/shipboard safety, NAVOSH,
and environmental programs. Stress the importance of safety information as it applies to upcoming summer cruises.
TITLE: Logs and Records Case Study

I. Learning Objectives
   A. The student will comprehend the moral and ethical responsibilities of a division officer.
   B. The student will comprehend the importance of integrity and moral courage in making ethical decisions.
   C. The student will comprehend a division officer's responsibility to support the command by doing what is ethically right.
   D. The student will comprehend the responsibility of the division officer to have the moral courage not to succumb to pressures that may lead to unethical behavior and the importance of leading the team to meet these common goals.
   E. The student will comprehend the following personal qualities and be able to relate them to a division officer's effectiveness:
      4. Loyalty
      5. Honor
      6. Integrity
      7. Courage (moral and physical)

II. References and Texts
   A. Instructor reference: Ethics for the Junior Officer, Issues 111 and 113
   B. Student text: None

III. Suggested Methods/Instructional Aids: Lecture enhanced with computer presentation and whiteboard/chalkboard

IV. Presentation
   A. Discuss reasons for maintaining engineering records.
      1. What are some of the reasons for maintaining a detailed record of plant settings, material
condition, temperatures, pressures etc.?

2. What is meant when a log is referred to as a “Legal Record”?

3. What is signified by a watchstander signing or initialing the log for the watchstation for which he or she is responsible?

B. Read pages 1 through 9, “Rationale for Acting Ethically,” and the case study entitled, “Specifications” (Issue 113), page 169, in Ethics for the Junior Officer.

C. Have students answer the following questions:

1. What might have led to this officer’s feeling that the reputation of the division is more important than the ethical question involved?

2. What options does this officer have available to him in dealing with this situation?

3. Is there a “big picture” issue here? For example, if it is command policy to report such out-of-specification readings to the commanding officer for trend analysis, why hasn’t the division reported this condition to the division officer? Should this concern him? Assuming this does concern him, what might his steps be in solving this problem?

D. Read the “What happened” section for Issue 113, "Specifications."

E. In this case, the division officer chose to not report the out-of-specification piece of equipment. Why was the reputation of the division more important than doing the right thing, when reporting the condition would have no negative consequences for the officer?

1. This particular piece of equipment’s out-of-spec condition did not present an equipment or personnel hazard. What might have been the ramifications if it had? Do you think the division officer's thought process would have been different? Should there be a distinction?

2. What should the division officer and his division have done to avoid this situation altogether?

3. Can one division officer standing up and doing the right thing make a difference for others who face the same situation in the future? Could you face
the pressure of making this decision?

F. If time permits, read and discuss Issue 111, “The Valve.”
Title: Ship Design and Engineering

I. Learning Objectives

A. The student will know the factors and criteria of ship design for seaworthiness, structural integrity, and operational employment and will comprehend design priorities used in construction of various warship types.

B. The student will know the following forces with regard to ship's structure: Stress, strain, shear, hogging and sagging.

C. The student will know the functions and nomenclature of the principal hull and structural members of a warship, including decks, shell plating, bulkheads, longitudinals, girders, beams, frames, floors, stem, bottom and keel structure.

D. The students will know the purpose of compartmentation and be able to interpret the present day compartment numbering system.

E. The student will know the basic structural components of a submarine.

F. The student will know the following types of propulsion plants.
   1. Conventional steam
   2. Diesel
   3. Gas turbine

G. The student will comprehend how ship stability and redundancy is designed into a ship before construction, including allowance for future needs.

H. The student will know considerations involved in the selection of materials for ship construction and the basics of structural design.

II. References and Texts

A. Instructor references

   1. Introduction to Naval Engineering, Chapter 20
2. *Principles of Naval Engineering*, Chapter 2

B. Student texts

1. *Principles of Naval Engineering*, Chapter 2
2. *Introduction to Naval Engineering*, Chapter 20

III. Suggested Methods/Instructional Aids

A. Lecture enhanced with computer presentation and whiteboard/chalkboard

B. Study Assignments

IV. Presentation

A. Basic design considerations

1. Seaworthiness
   a. Stability
   b. Displacement
   c. Freeboard
   d. Beam
   e. Hull shape
2. Structural integrity
   a. Engineering design
   b. Weight
   c. Resistance to operational stresses and strains
3. Operational employment
   a. Mission
   b. Armament
   c. Protection
   d. Maneuverability
   e. Cruising range
4. Tradeoffs because of design priorities
a. Cost
b. Life expectancy
c. Port facilities
d. Prime mover machinery/engineering design

B. The following is a discussion of forces encountered by a ship at sea. An analogy to a standard I beam may be useful.

1. Stress
   a. Tension
   b. Compression
   c. Shear
   d. Torsion

2. Strain: Distortion resulting from stress; usually expressed in inches/inch

3. Sagging
   a. Deck under compression
   b. Neutral axis experiences no stresses
   c. Bottom (keel) under tension

4. Hogging
   a. Deck under tension
   b. Neutral axis experiences no stresses
   c. Bottom (keel) under compression

C. Discuss the following principle structural elements of a warship. Use the analogy of the box girder.

1. Plating
2. Keel
3. Bottom
4. Framing
   a. Transverse frames
b. Longitudinal frames

5. Bulkheads

6. Decks

D. Discuss and interpret the compartmental numbering system.

1. System consists of four parts:
   a. Deck
   b. Frame
   c. Compartment
   d. Use

2. Deck: Main deck is the uppermost complete deck running the entire length of the ship; designated “1”
   a. Successive lower decks designated 1, 2, 3, etc.
   b. Successive upper decks designated 01, 02, 03, etc.

3. Frame: Frame number of forward bulkhead of compartment
   a. Frame numbers increase as one moves aft.
   b. If forward boundary is between frames, the frame number of the forward boundary is used.

4. Compartment
   a. Indicates the position of compartment relative to the ship’s centerline
   b. Centerline compartment designated “0”
   c. Successive even numbers to port
   d. Successive odd numbers to starboard

5. Compartment use
   a. Letter indicates primary use for space
   b. Double letters indicate spaces designed for
E. Discuss the basic structural components of a submarine.

1. The hull of a submarine consists of a watertight envelope designed to resist the predetermined operational hydrostatic pressure.

2. Structurally, members are the same as those in surface vessels with the exception of their thickness. Subs require thicker steel to withstand the great pressures encountered when operating at depths in excess of 800 feet.

3. U.S. submarines employ a single hull design. Advantages include:
   a. Larger interior volume
   b. Quieter

4. Ex-soviet submarines employ a two-hull design. Advantages include:
   a. Ease of fabrication
   b. Ability to absorb damage

5. Appendages form the final components unique to submarines.
   a. Control surface: Rudder, diving planes
   b. Free-flooding superstructure and fairwater

F. Construction material selection considerations

1. Strength and durability of materials
   a. Steel is most common for high strength
   b. Aluminum for corrosion resistance

2. Weight of materials

3. Cost and availability of materials
Title: Damage Control Systems and Equipment

I. Learning Objectives

A. The student will know the procedures, objectives, and priorities in combating the progressive deterioration from fire and underwater hull damage.

B. The student will know the four classes of fire and the fire fighting agents, equipment, and procedures to extinguish each class.

C. The student will know the use of equipment, materials, and procedures for countering progressive flooding and structural deterioration and demonstrate use while on summer cruise.

D. The student will know the principles of operation of the fire main system.

E. The student will know the procedures for donning and proper operation of the oxygen breathing apparatus (OBA) and self-contained breathing apparatus (SCBA) and demonstrate their use while on summer cruise.

II. References and Texts

A. Instructor references

1. *Introduction to Naval Engineering*, Chapter 26
2. *Principles of Naval Engineering*, Chapter 4

B. Student text: *Introduction to Naval Engineering*, Chapter 26

III. Instructional aids

A. Computer presentation

B. Damage control equipment, if available

C. Videos:

1. “Beating the Odds” (804635), 18 min
2. “Fire on the Flight Deck!” (806381), 26 min
D. VCR/Monitor

IV. Suggested methods and procedures: Have a Surface Warfare Officer present all or part of the damage control lecture.

V. Presentation

A. Review items listed in *Introduction to Naval Engineering*, Chapter 26, which the repair party should report to the DCA. Discuss the immediate local measures the repair party should perform.

B. Discuss the elements of the fire triangle:
   1. Fuel
   2. Heat
   3. Oxygen
   4. Free radicals

C. Describe the general characteristics of the four classes of fire:
   1. Class A: Wood, rubbish, paper
   2. Class B: Fuel, oil
   3. Class C: Electrical
   4. Class D: Metals, i.e., magnesium (any non A, B, C fire)

D. Discuss the firemain system.
   1. Receives water that is pumped from the sea
   2. Types of firemain systems:
      a. Single main -- small ships
      b. Horizontal loop
      c. Vertical loop
      d. Composite versions
   3. Primary purpose in fire fighting
   4. Uses other than fire fighting, i.e., flushing, auxiliary machinery cooling, water washdown

E. Discuss the fire station and its associated equipment,
including fireplug, quick cleaning strainer, all-purpose nozzle, vari-nozzle, and hoses.

F. Describe the extinguishing agent for each type of fire and cover in detail the types of equipment used.

1. Class A: Use of water
   a. Firemain system
   b. Sprinkler systems

2. Class B: Use of foam, PKP, Halon, steam or fog
   a. Aqueous film-forming foam (AFFF)
   b. Potassium bicarbonate (PKP)
   c. Twin agent extinguishing systems (AFFF/PKP)
   d. Halon 1301 system

3. Class C: Use of CO\(_2\)
   a. Portable CO\(_2\) extinguishers
   b. CO\(_2\) hose reel systems
   c. CO\(_2\) flooding systems

4. Class D: Use of solid stream, fog or jettison

G. Discuss the significance of flooding boundaries and systematic dewatering of flooded compartments.

1. Discuss the following:
   a. Progressive flooding
   b. Flooding boundaries
   c. Flooding may occur at locations far removed from the actual point of severe damage, from a torpedo hit for example, due to warping of structural members. So, the entire ship needs to be investigated after suffering damage.

2. Discuss some factors that should guide the priority of dewatering flooded compartments.
   a. Effective allocation of resources. (Do not work on compartments where the damage is too severe to allow containment.)
b. Stability

c. Flooding effect diagram

H. Discuss the various causes of flooding, the need to control it, and methods of water removal, including P-250 pump, electric submersible pump, and eductors.

I. Discuss the repair of structural damage, including shoring and patching.

J. Discuss the oxygen breathing apparatus (OBA) and self-contained breathing apparatus (SCBA) and compare them to a standard Navy gas mask.

1. Procedure for donning and operating
2. Capabilities
3. Circumstances under which OBA/SCBA should be worn

K. Discuss the safety precautions to be observed during damage control operations. Review dangerous situations to be aware of and avoid if/when possible:

1. Electric shock hazard if water is used on Class C fire
2. Exploding ordnance or fuels during fires
3. Splattering hot metal associated with the Class D fire
4. Being overcome by CO₂ or smoke
5. Heat stress conditions
LESSON GUIDE: 23                                      HOURS: 2

TITLE: Principles of Stability

I. Learning Objectives

A. The student will comprehend the concepts of hydrostatics, buoyancy, and Archimedes' principle.

B. The student will comprehend static equilibrium of a floating vessel and the relationship of the centers of gravity and buoyancy to righting arms and stability.

C. The student will comprehend and identify positive, negative and neutral conditions of stability.

D. The student will comprehend the effects of movements of the centers of gravity and buoyancy on vessel stability.

E. The student will know how ship's stability curves are derived and comprehend their use in determining stability condition.

F. The student will comprehend the effects of loose water on stability characteristics to include free surface effect and free communication effect.

II. References and Texts

A. Instructor references

1. Introduction to Naval Engineering, Chapter 22, pp. 389-400, 419 and Chapter 23, pp. 401-402

2. Principles of Naval Engineering, Chapter 3, pp. 3-1 through 3-10

B. Student texts

1. Introduction to Naval Engineering, Chapter 22, pp. 389-400, 419 and Chapter 23, pp. 401-402

2. Principles of Naval Engineering, Chapter 3, pp. 3-1 through 3-10

III. Suggested Methods/Instructional Aids

A. Lecture enhanced with computer presentation and whiteboard/chalkboard
B. Study Assignments

IV. Presentation

A. Describe the property of buoyancy. Include in your discussion:

1. Archimedes' Principle
2. Calculations of displacement (W)
3. The effect of salt water and fresh water on displacement (relate to draft)

B. Discuss the following:

1. Draft
2. Freeboard
3. Depth of hull
4. Reserve buoyancy

C. Define and discuss the following:

1. Stability reference points
   a. Keel (K)
   b. Center of buoyancy (B)
   c. Center of gravity (G). Explain how it moves with weight additions and shifts.
   d. Metacenter (M)

2. Linear measurements
   a. KG: Height of center of gravity above the keel
   b. KM: Height of metacenter
   c. GM: Metacentric height (measure of initial stability)

\[ GM = KM - KG \]

D. Discuss the three states of static equilibrium and relate them to metacentric height.

1. Positive stability: M above G
2. Neutral stability: M and G in same position
3. Negative stability: M below G

E. Define and discuss the following terms as they apply to overall stability:
1. Couple

2. Righting arm (GZ) \[ GZ = GM \sin \theta \]
3. Righting moment (RM) \[ RM = GZ (W) \]
4. Upsetting moment where: \[ \theta \] = angle of heel
   \[ W = \text{ship's displacement} \]

F. Discuss the development of the static stability curve from the cross curves of stability.
1. Factors involved:
   a. G does not change position as heel angle changes.
   b. B is always at the geometric center of the volume of the underwater hull.
   c. The shape of the underwater hull changes as heeling angle changes.
2. Effect of draft on righting arms:
   a. GZ decreases as a result of increased draft.
   b. Righting moments are decreased as a result of decreased GZ.
   c. Righting moments may increase with an increase in displacement.

G. Using stability curves show how to find:
1. Maximum righting arm (GZ)
2. Angle of heel where maximum GZ occurs
3. Range of stability
4. GM (graphically)

H. Define the following terms: roll, pitch, yaw, list, trim, center of flotation.
I. Define free surface effect and describe in detail:
   1. The vertical rise in the center of gravity
   2. The reduction in metacentric height
   3. The reduction in righting arm
   4. How to minimize free surface effect:
      a. Pocketing
      b. Longitudinal bulkheads to reduce breadth
      c. Surface permeability
      d. Swash bulkheads (good for quick rolling only)
      e. Completely full or empty tanks/compartment

J. Define free communication effect and describe in detail.
   1. The vertical rise in the center of gravity
   2. Relationship of compartment to ship centerline
   3. The reduction in metacentric height
   4. The added effect of the free surface effect
   5. Major determining factors in loss of righting arm:
      a. Area of free surface
      b. Perpendicular distance from geometric center
         of the free surface to ship centerline
Title: Maintenance Material Management and the Navy Supply System

I. Learning Objectives

A. The student will know the objective of the 3-M system and its PMS and MDCS subsystems, including the duties of the division officer and work center supervisor.

II. References and Texts

A. Instructor reference: OPNAVINST 4790.4 (Series), “Ships’ Maintenance Material Management (3-M) System Policy”

B. Student text: None

III. Suggested Methods/Instructional Aids: Lecture enhanced with computer presentation and whiteboard/chalkboard

IV. Presentation

A. 3-M system

1. Definition and purpose

2. Objective: To provide for managing maintenance and maintenance support in a manner that will ensure maximum equipment operational readiness

B. Discuss briefly the typical shipboard and aviation squadron maintenance management organization.

C. 3-M subsystem

1. PMS

   a. Definition and purpose

   b. Component parts: Discuss the principal planning and scheduling documents, as well as working guidelines to conduct maintenance.

   c. Associated terms

      (1) Corrective maintenance

      (2) Planned/preventive maintenance

      (3) Work center
(4) Work center supervisor

2. Maintenance data collection system
   a. Definition and purpose
   b. Interaction with supply system
   c. Components: Discuss main documents associated with reporting and maintenance history.

D. Benefits of PMS
   1. Increased equipment reliability
   2. Improved planning and management
   3. Simplified records
   4. Excellent training aid
   5. Continuity and standardization of maintenance
   6. Economy
   7. Increased safety

E. Problems of PMS
   1. Not self-starting nor self-sustaining
   2. Will not automatically and effortlessly produce good results
   3. Personnel shortage and turnover
   4. Training in maintenance required
   5. Occasional errors must be expected (though not necessarily accepted)

F. Discussion/Emphasis
   1. Overall importance of preventive maintenance and impact of 3-M on combat readiness
   2. Necessity of corrective action for deficiencies
   3. Responsibility for 3-M
      a. Division
      b. Work center supervisor
I. Learning Objectives
   
   A. The student will comprehend the moral and ethical responsibilities of a division officer.
   
   B. The student will comprehend the importance of integrity and moral courage in making ethical decisions.
   
   C. The student will comprehend a division officer's responsibility to support the command by doing what is ethically right.
   
   D. The student will comprehend the responsibility of the division officer to have the moral courage not to succumb to pressures that may lead to unethical behavior.
   
   E. The student will comprehend the following personal qualities and be able to relate them to a division officer's effectiveness:
      
      1. Loyalty
      2. Honor
      3. Integrity
      4. Courage (moral and physical)

II. References and Texts
   
   A. Instructor reference: Ethics for the Junior Officer, Issues 79 and 109
   
   B. Student text: None

III. Suggested Methods/Instructional Aids
   
   A. Lecture enhanced with computer presentation and whiteboard/chalkboard
   
   B. Study Assignments

IV. Presentation
   
   A. Discuss why a well-organized safety program is
important for personnel and equipment onboard ship.

1. Discuss situations that may warrant a tagout of equipment and refresh students’ memory on what is required to accomplish a tagout.

2. Discuss the ramifications of performing maintenance without following proper tagout procedures.
   a. Personnel injury
   b. Equipment damage

B. Read Issue 109, “Safety,” from Ethics for the Junior Officer. Facilitate discussion to include the following questions:

1. From the reading, develop a list of possible violations committed by the petty officer in performing maintenance on energized equipment without the permission of the commanding officer.

2. Despite the time savings, what significant issues did the division officer fail to take into account by first allowing the petty officer to perform the maintenance and then failing to take appropriate action after it was completed?

3. Consider that the petty officer had at least one person junior to him either assisting in the maintenance or observing. What questions does this bring to mind with regard to good order and discipline?

4. What would you do in this situation? Would you do anything, or do you agree with the actions of the officer in question?

C. Read the “What happened” section for Issue 109, "Safety." Facilitate discussion to include the following questions:

1. What policy statement is being made by the junior officer if he ignores or commends the actions of the individuals who performed the unauthorized maintenance?

2. Why is the age of the junior officer brought up as an issue in the “What happened” section?

3. What happens when a clearly defined chain of command breaks down, as may have happened in this situation?
4. Is it possible for the junior officer to report the petty officer and still maintain the professional respect and rapport necessary to keep the division running at peak performance?

5. What would have happened if the junior officer, knowing that he had condoned this behavior, had suddenly turned on the petty officer and referred the case to Captain’s Mast, effectually hanging the individual "out to dry."

D. In a 5-minute “free write,” have the students write a short paragraph indicating what they have learned through this case study, what additional questions they have about it, or what further questions they would have raised for the discussion.

E. Read Issue 79, "Training," on page 115 of Ethics for the Junior Officer. Facilitate discussion to include the following questions:

1. Why should it be important to you as a junior officer to ensure that training is conducted as planned and not just what there is time for?

2. If there were a mishap later in the training cycle, and the results of the investigation pointed out that the individual involved was poorly trained, who could/would be held partially accountable?

3. Can you explain why someone who is only responsible for documentation of the training can be held accountable if it doesn’t occur? Does a system of “checks and balances” mean anything in this situation?

4. In filling out the training critique form and indicating completion of the required training (when it has not been completed), what has the trainer effectively done?

5. Why might the completion of the training documentation form become more important than the training itself?
   a. Couldn’t you just roll with the system? The completion of the training is the responsibility of the division, not the training coordinator.
   b. How might you convince the guilty parties that it is more important to document
incomplete training than to document completion when it has not actually been completed?

c. How was peer pressure involved in this evolution?

F. Read the “What happened” section for Issue 79, "Gundecking." Facilitate discussion to include the following questions:

1. The JO involved chose to return the falsified training report with a note that all further training would be documented as conducted. Did he give this officer a break? What other actions might he have taken?

2. By indicating that he will monitor training from this day forward, he has effectively let the officers "off the hook" for previous transgressions. Although this is not the most correct approach (since they could have been reported for falsifying documents), why will it probably have the most benefit?

3. We have a tendency to forget our oath of office and its effect on the conduct of our jobs on a day-to-day basis. Can you see how a junior officer letting down his guard can have a great effect, both positively and negatively, on daily business within his command?

4. To what other situations might this type of incident have application?

   a. Can you see a similar situation occurring within the planned maintenance system?

      (1) Is it conceivable that junior officers who do not maintain a close watch on the maintenance being conducted could actually be signing off on incomplete requirements?

      (2) If the above is occurring, what are the ramifications, and are they more serious than improper documentation of training. Why?

   b. What other situations can you think of where these conditions can occur?