

Bachelor of Science in Marine Engineering  
**COURSE FRAMEWORK**

Course Title:	Basic Control Engineering	
Course Code:	Auto 1	
Pre-requisites:	Electro 2& Mechanics	
Effective Date:		
Date Created		Revision No.: 0
Prepared by:	Checked by:	Approved by:
Engr WM Cawagas III MEP-MEM	C/E Alexander V. Tabobo Dean, College of Marine Engineering	Dr. Ronald D. Barro, D. Eng Asst. Supt. - ATRE

### 1. Scope and Purpose:

This course covers the knowledge, understanding and proficiency of the basic control engineering; the operation, maintenance and repair of electrical, electronic and control systems. The competencies covered in this course is in accordance with STCW '78 code as amended. It aims to provide students with necessary knowledge, understanding and proficiency listed under column 2 of table A-III/1 and A-III/2, as listed on the table below;

Table No.	Function	Competence (under column 1)
A-III/1	Marine Engineering at the operational level;	Operate main and auxiliary machinery and associated control systems
	Electrical, Electronic and Control Engineering at the operational level;	Operate electrical, electronic and control systems
		Maintenance and repair of electrical and electronic equipment
A-III/2	Electrical, Electronic and control Engineering at the management level	Manage operation of electrical and electronic control equipment
		Detect and identify the cause of malfunctions and correct faults

### 2. Program Outcomes

A graduate of BS Mar E shall be able to demonstrate the ability to perform the competence, at the operational level under Table A-III/1 and some elements of Table A-III/2 of the STCW Code.

*Graduates of this course (BS Mar E) should be able to:*

- Engage in lifelong learning and understanding of the need to keep abreast of the development in maritime practice;
- Communicate orally and in writing both English and Filipino;
- Work independently and in multidisciplinary and in multicultural teams;
- Act in recognition and practice of professional, social and ethical accountability and responsibility; and;
- Preserve and promote "Filipino historical and cultural heritage"

*Furthermore, a graduate of this program should be able to:*

- a.) Apply knowledge in mathematics, science and technology in solving problems related to the profession and the workplace;
- b.) Evaluate the impact and implications of various contemporary issues in the global and social context of the profession;
- c.) Engaged in lifelong learning and keep abreast with developments in the field of specialization and/or profession;
- d.) Use appropriate techniques, skills and modern tools in the practice of the profession in order to remain globally competitive;
- e.) Conduct research using appropriate research methodology.

### **3. Course Intended Learning Outcomes (CO):**

By the end of this Course, students should be able to;

CO1: Differentiate basic construction and principles in automation regarding various measuring instruments and automation devices used onboard ships.

CO2: Interpret process and instrument diagrams of automation system based on the industry standards

CO3: Demonstrate performance test in accordance with the manufacturers standards for the: monitoring systems; automatic control devices; and protective devices

### **4. Entry Standard**

The course is intended for students who are enrolled on Bachelor of Science in Marine Engineering (BS Mar E) and must be a holder of diploma in secondary education and passed the medical examination as prescribed by the Department of Health and the Norwegian Maritime Authority. Second coursers (those who have graduated from other higher education programs) who intend to pursue Maritime Studies and have satisfied the abovementioned requirement is also accepted to take this course. The necessary pre-requisite for this subject is Electro1.

### **5. Target Groups**

The target groups of this course are those students who are currently enrolled in Bachelor of Science in Marine Engineering Program (BSMarE) and must have taken the necessary pre-requisite of this course which is Electro1.

### **6. Class Limitation:**

A maximum of twenty-five (25) students in a lecture/laboratory class with a room size equivalent to a ratio of 2 m<sup>2</sup> /student (an approximate area of 50m<sup>2</sup>) is allowed. Equipment to student ratio must be 4:1

A designated instructor is assigned for a lecture/laboratory class of 25 students. Laboratory class should have a designated instructor for 20 students. Should the number of students exceed the maximum of 20, there must be an assistant laboratory instructor provided the ratio of equipment to student stated above is observed.

### **7. Staff requirements**

To maintain a standard and quality level of teaching, faculty members/instructor teaching **Professional Courses** shall be holders of relevant academic degree, experiences and credentials as follows:

**A. Instructor:**

1. Must have a degree in BSECE/BSEE and a holder of *IMO Model Course 6.09* certificate
2. Twelve (12) months as OIC EW on seagoing ship powered by main propulsion machinery of 750kW propulsion power or more.
3. Must have a degree in BSMarE and a holder of *IMO Model Course 6.09* certificate
4. Boatswain, fitter, able seaman (Engine) with at least three (3) years seagoing practice shall be allowed to conduct skills laboratory classes under supervision of a lead instructor. (CMO67 s2017)
5. Allied faculty members teaching courses which fall under the category of professional as enumerated under *section 6.5 of CMO 67 s2017* shall be holders of the following:
  - a. Appropriate bachelor's degree in such allied fields
  - b. Valid certificate of registration and/or PRC license of his/her profession and Certificate of Completion of the "Training Course for Instructor" (*IMO Model Course 6.09*)
6. Faculty members teaching courses involving the use of simulators, in addition to the preceding requirements shall:
  - a. Be holders of Certificate of Completion of the "Train the Simulator Trainer and Assessor Course" (*IMO Model Course 6.10*) or an approved training course for simulator instructors and Assessors by the Philippines' STCW administration
  - b. Have gained practical operational experience on the particular type of simulator being used. This requirement may be satisfied through a planned in-house training of the *Maritime Higher Education Institution* (MHEI) or the transfer of technology training by the simulator supplier.

**B. Assessors:**

The designated assessors shall have an appropriate level of knowledge and understanding of the competence to be assessed and be qualified for the task for which the assessment is being made.

The Assessors should possess the following qualifications:

1. Have an appropriate level of knowledge and understanding of the competence to be assessed.
2. Be qualified for the task for which the assessment is being made
3. Have undergone training in:
  - a. "*Training Course for Instructors*" (*IMO Model Course 6.09*)
  - b. "*Assessment, Examination and Certification of Seafarers*" (*IMO Model Course 3.12*),
  - c. "*Train the Simulator Trainer and Assessors Course*" (*IMO Model Course 6.10*) or an approved Training course for Simulator Instructors and Assessors by the Philippines' STCW Administration for those assessing competence using simulators;
4. Gained practical experience (e.g. teaching for at least one semester in the related subject or as assistant to an experienced assessor for at least one semester)

5. Gained practical assessment experience on the particular type of simulator under supervision and to the satisfaction of an experienced assessor for assessments involving the use of simulators.

#### **8. Promotion Document:**

A student who acquired a passing grade of 70% (pass) in the final will be eligible to enroll the subject to which this course is a requisite as per *CMO 67 s2017* grading requirements.

#### **9. Teaching Methodologies:**

For the fulfillment of the course the teaching and learning methodologies shall be the variation of the following strategies.

- a. Film/Video Viewing
- b. Brain Storming
- c. Interactive Learning
- d. Class Discussion/Question & Answer Technique
- e. Focused Group Discussion
- f. Workshop Activities
- g. Research Project
- h. Quizzes and Periodic Examination
- i. Demonstration of competences (workshop activities)

#### **10. Grading System/Examination and Assessment:**

- Written Examination
- Practical Assessment
- Research Outputs

#### **11. Teaching Facilities and Equipment:**

##### **A. Teaching Facilities**

For the conduct of lecture, a well-lighted classroom with an approximate size of 50m<sup>2</sup> (2m<sup>2</sup> size :1 student) equipped with white board or blackboard, multimedia (*LCD projector or at least 55-inch TV set, speaker system*) and computer set.

##### **B. List of Equipment/tools and accessories (B):**

For the laboratory activities, a laboratory room with an area to student ratio of **2m<sup>2</sup>:1** (50m<sup>2</sup>) is necessary with the following equipment.

- B1: 14 sets digital multi testers
- B2: 7 sets analog multitesters
- B3: 30 sets/pairs of eye goggles 1:1
- B4: 7stations PIDSIMULATOR
- B5: 30 sets pair of rubberhand gloves 1:1
- B6: 7 units Fluke 724/725 temp. Calibrator
- B7: 7 sets thermocouple sensor + transmitter with 0 to 200<sup>o</sup>C range
- B8: 7 sets Pt100 sensor + transmitter with 0 to 200<sup>o</sup>C range
- B9: 7 units pressure switch with 10bar maximum pressure capacity
- B10: 7 units of electronic differential pressure transmitters
- B11: 7 units pneumatic pressure transmitters

- B12: 7 units float switch  
 B15: 7 sets precision screw drivers  
 B16: 7stations calibration workbench  
 B17: 7sets open wrench  
*\*\*\*note: it is economical to buy set of open wrenches rather than buying it in individual sizes.*  
 B18: 14-units thermometer 0 to 200<sup>0</sup>C range  
 B19: 7 stations Pneumatic power supply of 7 bars pressure with pressure regulator available in each calibration workbench  
 B20: 7-unitsvariable DC power supply Maximum range of 30V  
 B21: 1 First aid box accessible in the tool room with (betadine solution, gauze bandage, tourniquet,band aid strips, alcohol, cotton, eye wash (table salt, borax powder))  
*\*\*\*note: If it is possible for the school to buy one (1) first aid kit (small cabinet/box) located in the shop room with the contents stated above. This is intended for emergency first aid although schools have its own clinic with complete medical staff.*  
 B22: 1-unit Boiler system  
 B23: 7 units motor starter station with complete components  
 B24: 7units' electric heater (boiler pot)  
 B25: 7 units ice vat (plastic container)  
 B26: 15 lengths 1-m long 6 mm flexible hose  
 B27: 7- pieces pail or a transparent tank  
 B28: 7- pieces differential pressure calibrator or (graduated tank calibrator transparent)  
 B29: 7 stations electronic workbench complete with components  
 B30: 7 units Pressure Gauge 0 - 2.5 bar range  
 B31: 14 units pressure regulator 0 –10 bar range  
 B32: 7 pieces negative screw drivers  
 B33: 20 pieces T connector for 6 mm hose  
 B34: 7-unit diaphragm control valve  
 B35: 7 stations FESTO FLUID SIMULATOR  
 B36: 7 units 3Φ motor 220Vac  
 B37: 7 units positive screw drivers  
 B38: 7 computer sets with internet access  
 B39: 25 sets Scientific Calculator

## **C. Teaching Aids**

### **i. List of Manuals (M)**

- M1: Machinery Operating Manual“*Hoegh Galleon*”  
 M2: Workshop Skills Activity Manuals  
 M3: PT100 Resistance Table  
 M4: TC” K” Thermocouple Table  
 M5: RT116 Nomogram  
 M6: 11GM Foxboro Pneumatic Transmitter  
 M7: 1151 Alphaline Pressure Transmitter  
 M8: Fluke 724 User’s Manual

### **ii. List of Videos (V)**

*The following videos can be viewed as integral part of the prescribed learning objectives. Credits to YouTube for all video materials*

Video No.	W#D #	Title	Time (min)	Source
V1	1-1	Automation Alert Maritime Education	6:20	<a href="https://www.youtube.com/watch?v=wOUxR-uwHgQ">https://www.youtube.com/watch?v=wOUxR-uwHgQ</a>
V2	1-2	Basics of Automation	2:09	<a href="https://www.youtube.com/watch?v=X5fD0Evny4w">https://www.youtube.com/watch?v=X5fD0Evny4w</a>
V3	2-1	Feedback Control Systems	5:56	<a href="https://www.youtube.com/watch?v=5NVjIli9fkY">https://www.youtube.com/watch?v=5NVjIli9fkY</a>
V4	2-2	Feedback and Feedforward	27:36	<a href="https://www.youtube.com/watch?v=vLzXl0omtAg">https://www.youtube.com/watch?v=vLzXl0omtAg</a>
V5	3-1	What is a pressure switch	3:49	<a href="https://www.youtube.com/watch?v=ZBqcluiaK8M">https://www.youtube.com/watch?v=ZBqcluiaK8M</a>
V6	3-2	How to adjust a pressure switch	7:57	<a href="https://www.youtube.com/watch?v=1VNSv7xVzzU">https://www.youtube.com/watch?v=1VNSv7xVzzU</a>
V7		Hydrophore unit	1:22	<a href="https://www.youtube.com/watch?v=2j-q5vGv_mY">https://www.youtube.com/watch?v=2j-q5vGv_mY</a>
V8	4-1	Sequential Control of motors	1:59	<a href="https://www.youtube.com/watch?v=ZSFJSqWr578">https://www.youtube.com/watch?v=ZSFJSqWr578</a>
V9	5-1	PID Controller	5:38	<a href="https://www.youtube.com/watch?v=sFqFrmMJ-sg">https://www.youtube.com/watch?v=sFqFrmMJ-sg</a>
V10	5-2	Proportional Gain	3:55	<a href="https://www.youtube.com/watch?v=2Nrgms0cKs4">https://www.youtube.com/watch?v=2Nrgms0cKs4</a>
V11	6-1	PIDs Simplified	13:06	<a href="https://www.youtube.com/watch?v=6OH-wOsVVjg">https://www.youtube.com/watch?v=6OH-wOsVVjg</a>
V12	6-2	Understanding PID in 4 minutes	3:39	<a href="https://www.youtube.com/watch?v=wbmEUi2p-nA">https://www.youtube.com/watch?v=wbmEUi2p-nA</a>
V13	7-1	How Bimetallic Thermometer Works	6:20	<a href="https://www.youtube.com/watch?v=6Am3lqOGCuA">https://www.youtube.com/watch?v=6Am3lqOGCuA</a>
V14	7-2	How Bulb Thermometer Work	4:05	<a href="https://www.youtube.com/watch?v=Blcf-w0MkY0">https://www.youtube.com/watch?v=Blcf-w0MkY0</a>
V15	8-1	Types of Temperature Sensors	4:27	<a href="https://www.youtube.com/watch?v=Pahi-Ee9vkA">https://www.youtube.com/watch?v=Pahi-Ee9vkA</a>
V16	9-1	How Fluid Pressure is Measured	11:10	<a href="https://www.youtube.com/watch?v=y9B0NqNF11I">https://www.youtube.com/watch?v=y9B0NqNF11I</a>
V17	9-2	How a Bourdon Type pressure gauge work	7:33	<a href="https://www.youtube.com/watch?v=Ja_XCJAgl8">https://www.youtube.com/watch?v=Ja_XCJAgl8</a>
V18	10-1	Ball Float Liquid Level Sensor	4:20	<a href="https://www.youtube.com/watch?v=53hGjRBFj40&amp;list=PLGQSEUjPOaYYViK8Be_X39Wsfp_Qkley5&amp;index=2">https://www.youtube.com/watch?v=53hGjRBFj40&amp;list=PLGQSEUjPOaYYViK8Be_X39Wsfp_Qkley5&amp;index=2</a>
V19	10-2	Level Measurement Using DP Transmitter	6:14	<a href="https://www.youtube.com/watch?v=XWfwg9WcWfo&amp;t=295s">https://www.youtube.com/watch?v=XWfwg9WcWfo&amp;t=295s</a>
V20	11-1	DP Flow Measurements venturi	4:49	<a href="https://www.youtube.com/watch?v=oUd4WxjoHKY">https://www.youtube.com/watch?v=oUd4WxjoHKY</a>
V21		DP Flow measurement Pitot	4:36	<a href="https://www.youtube.com/watch?v=D6sbzkYq3_c">https://www.youtube.com/watch?v=D6sbzkYq3_c</a>
V22	11-2	Rotameter Working Principle	3:24	<a href="https://www.youtube.com/watch?v=ELJoieQDe6w">https://www.youtube.com/watch?v=ELJoieQDe6w</a>
V23	12-1	Inductive Type Tachometer	5:39	<a href="https://www.youtube.com/watch?v=37oJtcUTpL8">https://www.youtube.com/watch?v=37oJtcUTpL8</a>
V24	13-1	Vibration Monitoring	16:7	<a href="https://www.youtube.com/watch?v=wuTthiAiqFk">https://www.youtube.com/watch?v=wuTthiAiqFk</a>
V25	13-2	Open Tank Level Measurement	17:9	<a href="https://www.youtube.com/watch?v=xfo9n_ly8sA">https://www.youtube.com/watch?v=xfo9n_ly8sA</a>
V26		Why 4 to 20 mA	3:38	<a href="https://www.youtube.com/watch?v=ZWA3srlVwnw">https://www.youtube.com/watch?v=ZWA3srlVwnw</a>
V27	14-1	3 basic Pneumatic mechanism for	4:40	<a href="https://www.youtube.com/watch?v=8_UPBYuc">https://www.youtube.com/watch?v=8_UPBYuc</a>

		pneumatic controller		UM0&t=35s
<b>V28</b>	14-2	Servo motors	2:27	<a href="https://www.youtube.com/watch?v=hYu9fGE4pCk">https://www.youtube.com/watch?v=hYu9fGE4pCk</a>
<b>V29</b>	15-1	Control valves	1:41	<a href="https://www.youtube.com/watch?v=XAItnsUcES0">https://www.youtube.com/watch?v=XAItnsUcES0</a>
<b>V30</b>		How Diaphragm Control Valves Work	5:28	<a href="https://www.youtube.com/watch?v=dxelSWY6bHg">https://www.youtube.com/watch?v=dxelSWY6bHg</a>
<b>V31</b>	15-2	What are valve positioners	3:41	<a href="https://www.youtube.com/watch?v=dNq4H9WfrfE&amp;t=21s">https://www.youtube.com/watch?v=dNq4H9WfrfE&amp;t=21s</a>
<b>V32</b>		Calibration of positioner	11:28	<a href="https://www.youtube.com/watch?v=CjFfCesJ5xo">https://www.youtube.com/watch?v=CjFfCesJ5xo</a>
<b>V33</b>	16-1	Swash plate pump	5:27	<a href="https://www.youtube.com/watch?v=le-VolW-QE8">https://www.youtube.com/watch?v=le-VolW-QE8</a>

### iii. List of Workshop Skills Activities (WSA):

Week No.	Title	WSA No.	Equipment Needed
1	Block Diagram of an Automatic Control System	1	B22
2	Feedback Control Systems	2	B22
3	ON-OFF Control	3	B1, B3, B5, B9, B23, B35, B36
4	Sequential Control	4	B35
5	Performance Check of a PID Controller	5	B4
6	Controller Tuning	6	B4
7	Performance Test of an PT100 (RTD) Sensor	7	B1, B8, B16, B18, B24, B25, M3
	Calibration of a PT100 (RTD) Transmitter	8	B6, B8, B15, B16, M8
8	Midterm Practical Assessment	xx	B6, B8, B15, B16, M8
9	Performance Test of TC “K” Sensor	9	B1, B7, B16 B18, B24, B25, M4
	Calibration of a TC” K” Transmitter	10	B6, B7, B15, B16, M8
	Performance Test of a Pressure Switch	11	B1, B9, B16, B19, B26, B37, M5
10	Performance test of a Float Level Sensor	12	B1, B12, B16, B23, B26
11	Performance Test of a DP Transmitter	13	B1, B10, B15, B17, B20, B23, B27, M7
12	Boiler Flame Scanner (Photocell)	14	B1, B20, B29
13	Performance test of a Pneumatic Pressure Transmitter	15	B11, B17, B19, B26, B30, B31, B32, B33, M6
14	AC and DC Servomotors	16	B38
15	Diaphragm Operated Control Valve	17	B4, B38
16	Compilation of Workshop Skills Activity	18	WSA #18 manual
	Final Practical Evaluation	xx	B1, B4, B9, B16, B17, B19, B31

### iv. List of power point presentation: (PPT)

No.	Week No. Day No.	Title:
PPT 1	W1-D1	Fundamentals of Automatic Control
PPT 2	W1-D2	Various Automatic Control

PPT 3	W2-D1	Control Methodology
PPT 4	W2-D2	Types of Control Strategy
PPT 5	W3-D1	On-Off Controls
PPT 6	W3-D2	On-Off Controls
PPT 7	W4-D1	Sequential control
PPT 8	W5-D1	PID Control
PPT 9	W5-D2	PLC and PID Controller
PPT 10	W6-D1	Characteristics of PID control
PPT 11	W6-D2	PID Controller Actions
PPT 12	W7-D1	Temperature Measurement
PPT 13	W7-D2	Mechanical Thermometers
PPT 14	W8-D1	Electrical Thermometers
PPT 15	W9-D1	Pressure Measurement
PPT 16	W9-D2	Bourdon Tubes
PPT 17	W10-D1	Level measurement- Direct
PPT 18	W10-2	Level Measurement- Inferential
PPT 19	W11-D1	Flow Measurement
PPT 20	W11-D2	Flow Measurement contd.
PPT 21	W12-D1	General Measurement of Process
PPT 22	W13-D1	General Measurement of Process contd.
PPT 23	W13-D2	Transmitters
PPT 24	W14-D1	Pneumatic Controlling Elements
PPT 25	W14-D2	Receivers
PPT 26	W15-D1	Pneumatic Manipulating Element
PPT 27	W15-D2	Valve Positioner
PPT 28	W16-D1	Electrical Servomotors

**v. List of Simulators (S)**

S1: FESTO Fluid Simulator

S2: PID Simulator

**vi. List of weekly quizzes (Q):**

Quiz #	Week #-Day#	No. of Items	Duration (min)
1	W1-D2	10	15
2	W2-D2	10	15



<b>3</b>	W3-D3	10	15
<b>4</b>	W5-D2	10	15
<b>5</b>	W5-D2	10	15
<b>6</b>	W7-D2	10	15
<b>7</b>	W9-D2	10	15
<b>8</b>	W10-D2	10	15
<b>9</b>	W11-D2	10	15
<b>10</b>	W13-D2	10	15
<b>11</b>	W14-D2	10	15
<b>12</b>	W15-D2	10	15

**vii. List of term Exams**

<b>No.</b>	<b>Title</b>	<b>Week#-Day#</b>	<b>Items</b>			<b>Duration (min)</b>
			<b>Multiple Choice</b>	<b>Essay</b>	<b>Total</b>	
<b>1</b>	Prelim Exam	W4-D2	40	10	50	75
<b>2</b>	Midterm Exam	W8-D2	40	10	50	75
<b>3</b>	Semi Final Exam	W12-D2	40	10	50	75
<b>4</b>	Final Exam	W16-D2	160	10	170	75

**viii. List of practical Assessment (PA):**

<b>No.</b>	<b>Title</b>	<b>Week#-Day#</b>	<b>Duration Min</b>
<b>1</b>	Midterm PA: Calibration of Pt100 Transmitter	W8-D3	
<b>2</b>	Final PA set#1: Controller tuning	W16-D3	
<b>3</b>	Final PA set#2: Calibration of Pressure Switch (for retake purposes)	W16-D3	

**ix. Textbooks:**

The textbooks listed below should have at least 25 copies found on the library.

T1: Instrumentation and Control Systems (or latest edition)  
Vol.10 of Reed's Marine Engineering Series  
by:Leslie Jackson c2011  
ISBN 978-0-7136-6731-8

**x. Supplementary Readings:**

SR1: Control Fundamentals  
SR2: Control 101

**xi. Website references:**

W1: <http://www.ent.mrt.ac.lk/~rohan/teaching/EN5001/Reading/DORFCH1.pdf>  
W2: <http://www.srmuniv.ac.in/sites/default/files/2018/Process-Control-Lab.pdf>  
W3: <http://blog.opticontrols.com/archives/297>  
W4: <http://www.shippedia.com/ship-automation-control-system/>  
W5: [https://www.coulton.com/What\\_is\\_On\\_Off\\_Control.html](https://www.coulton.com/What_is_On_Off_Control.html)  
W6: <https://motor-control-circuits.blogspot.com/2015/03/sequential-control-3-stages.html>  
W7: <https://www.dataforth.com/introduction-to-pid-control.aspx>  
W8: <https://www.eurotherm.com/plc-or-pid-controller-whats-the-difference-and-how-do-you-decide-what-technology-you-need>  
W9: <http://www.instrumentationtoday.com/optical-pyrometer/2011/08/>  
W10: [https://en.wikipedia.org/wiki/Pressure\\_measurement](https://en.wikipedia.org/wiki/Pressure_measurement)  
W11: <https://blog.beamex.com/how-to-calibrate-pressure-gauges>  
W12: <http://aboutinstrumentation.blogspot.com/2012/02/level-measurement-direct-methods.html>  
W13: <https://paktechpoint.com/indirect-level-measurement-methods-paktechpoint/>  
W14: [https://en.wikipedia.org/wiki/Flow\\_measurement](https://en.wikipedia.org/wiki/Flow_measurement)  
W15: <https://en.wikipedia.org/wiki/Rotameter>  
W16: <https://www.marineinsight.com/main-engine/how-to-prevent-crankcase-explosion-on-a-ship/>  
W17: <https://www.instrumentationtoolbox.com/2013/06/transmitters-used-in-process.html>  
W18: [https://en.wikipedia.org/wiki/Chart\\_recorder](https://en.wikipedia.org/wiki/Chart_recorder)  
W19: [https://en.wikipedia.org/wiki/Pneumatic\\_actuator](https://en.wikipedia.org/wiki/Pneumatic_actuator)  
W20: <https://www.watelectrical.com/servo-motor-types-and-working-principle/>

## **12. IMO/CHED References:**

R1. STCW '78 as amended 2017 ed.  
R2: IMO MODEL COURSE 7.02  
R3: IMO MODEL COURSE 7.04  
R4: CMO 67, S. 2017  
R5: Annex C of CMO 67, S.2017  
R6: Annex D of CMO 67, S. 2017  
R7: CMO14 series of 2018

\*\*\*\*\*Nothing follows\*\*\*\*\*