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DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA
MINISTRY OF PORTS AND SHIPPING
MERCHANT SHIPPING SECRETARIAT
Examination for Officer in Charge of an Engineering Watch on Ships of 200 kW
Propulsion Power or More



MARINE ENGINEERING DRAWING AND DESIGN

- TIME ALLOWED - FOUR HOURS
- Answer All Questions

Date: 2021.....



Pass marks: 50%

Answers with clear sketches/diagrams, neat handwriting and clear expression will get full marks

The pictorial drawing shows details of a **Cylinder Relief Valve** for preventing the rupture of a normally pressurized cylinder.

Draw the following views of the assembled **Cylinder Relief Valve** in **first angle projection**. Select a suitable scale.

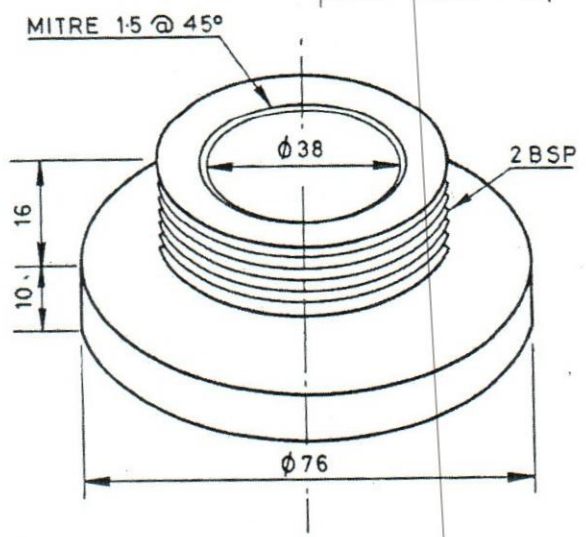
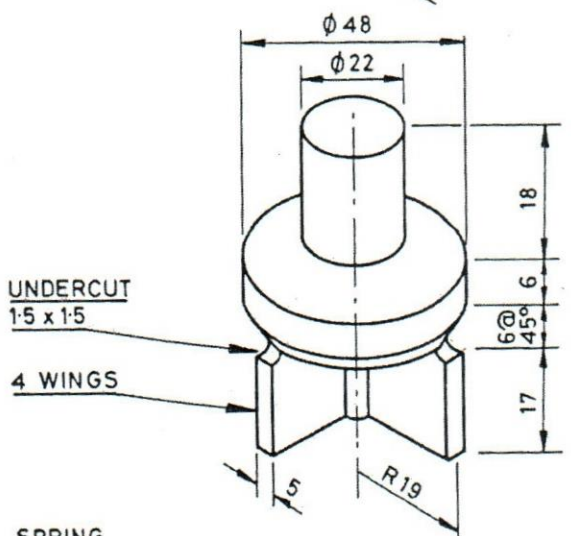
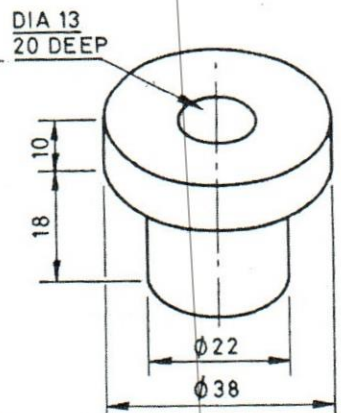
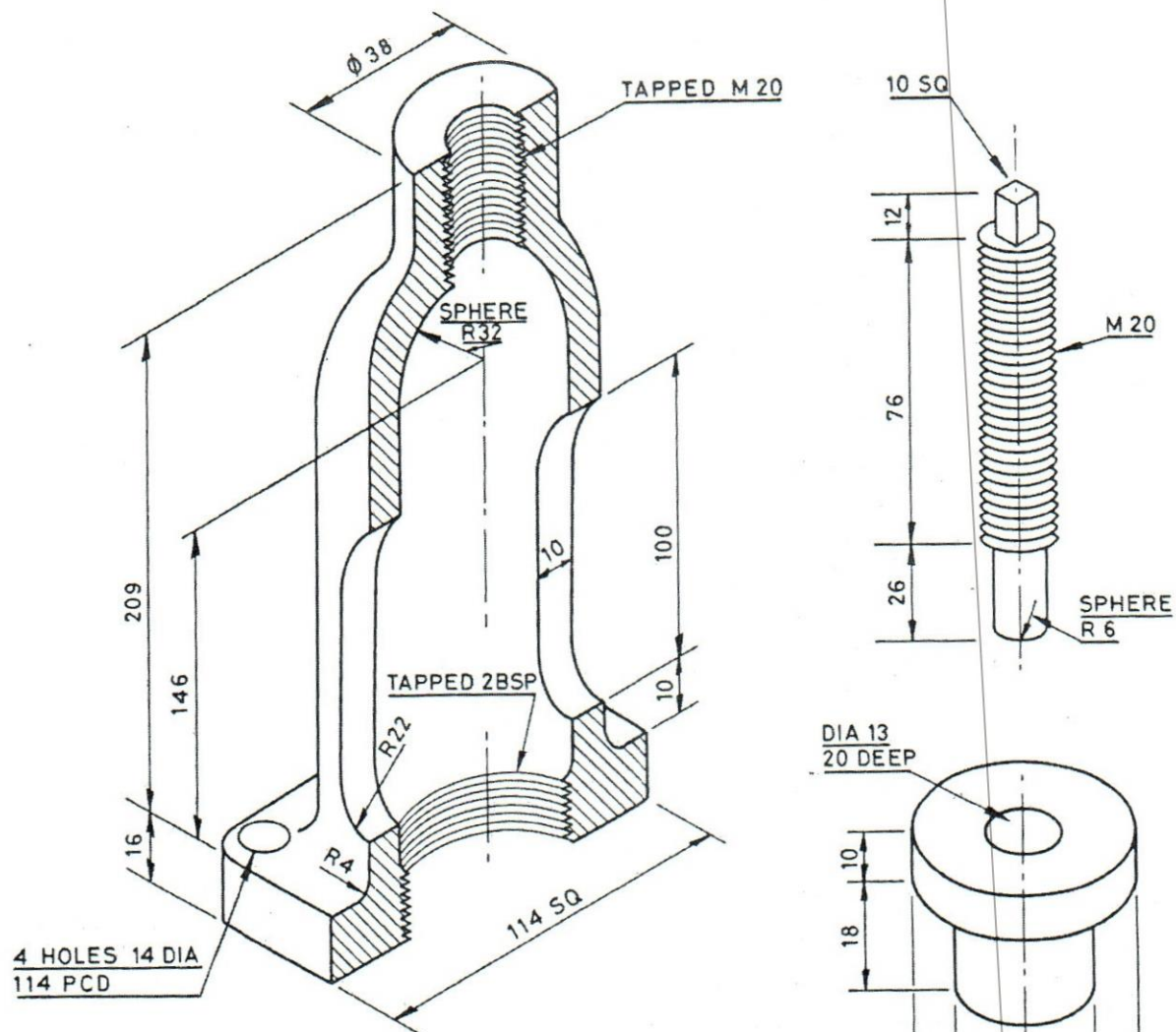
- (a) The sectional front elevation showing the valve assembled.
- (b) End elevation projected to the right
- (c) Plan

Spring should be shown in free length. Draw M20 lock nut with the adjusting screw. Complete the drawing by adding dimensions, title box, and projection symbol.

Suitable dimensions should be estimated where not provided. Hidden details are not required in any view. Complete the drawing by including the title, projection symbol and dimensions.

Marking System

- | | |
|---|------------|
| (a) Assembling accuracy of view (a) | (40 marks) |
| (b) Assembling accuracy of view (b) | (25 marks) |
| (c) Assembling accuracy of view (c) | (15 marks) |
| (d) Optimization of space | (05 marks) |
| (e) Dimensioning (at least 12 dimensions correctly) | (05 marks) |
| (f) Title block, projection symbol, lettering | (05 marks) |
| (g) Final appearance | (05 marks) |



SPRING
 FREE LENGTH 146
 LENGTH COMPRESSED 127
 MEAN DIA 32
 DIA OF WIRE 8

CYLINDER RELIEF VALVE

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DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA
MINISTRY OF PORTS AND SHIPPING
MERCHANT SHIPPING SECRETARIAT
Examination for Officer in Charge of an Engineering Watch on Ships of 750kW
Propulsion Power or More


Maritime Law

- TIME ALLOWED - THREE HOURS
- Answer SIX questions only
- Date: 2021.....

Pass marks: 50%

Answers with clear sketches/diagrams, neat handwriting and clear expression will get full marks

1. Referring to Risk Management on board ships,
 - a. Name the four (04) main steps of risk management process. (02 Marks)
 - b. Briefly explain above four (04) steps. (06 Marks)
 - c. Make a risk assessment and state the control measures that you would propose when team of riding technicians boarded the vessel for carrying out essential generator repair, taking into consideration the present Corona pandemic. (08 Marks)
2. With reference to SOLAS requirements State;
 - a. The test carried out to verify the capacity of the steering gear system of a cargo ship. (07 Marks)
 - b. The routine inspection & tests required to carry out on steering gear system of a ship. (07 Marks)
 - c. State the frequency of above routine inspection & tests required to be carried out. (02 Marks)
3. With reference to SOLAS Ch II -2 requirements State;
 - a. State the safety requirement applicable the for the CO2 (Multi-bottle system) Room. (04 Marks)
 - b. What should be the minimum capacity of CO2 multi-bottle total flooding system for machinery space and Cargo space of cargo ship? (04 Marks)
 - c. State the periodical test requirement applicable for above systems? (08 Marks)
4.
 - a. State the four (04) main objectives of the International Load Line Convention, assigning a minimum "Free Board" for a sea going ship. (04 Marks)

- 
- b. What is meant by "Floodable Length" of a ship? (03 Marks)
- c. What is meant by "Permeability of a Compartment"? (03 Marks)
- d. State various items on board ship which are subjected to examine during load line survey. (06 Marks)
5. Certificates are issued to merchant ships to indicate their compliance with International, National & Classification Regulations & Rule requirements.
- a. State the three main categories of certificates issued to ships. (03 Marks)
- b. What are the areas/items covered under each of the categories of certificates stated above? (07 Marks)
- c. What is mean by "Statutory Certificate"? (02 Marks)
- d. State 04 advantages of Harmonized Ship Survey & Certification system. (04 Marks)
6. Regarding SOLAS requirements for watertight doors fitted on watertight bulkheads in cargo ships, State.
- a. Classes (Types) of watertight doors. (03 Marks)
- b. Maximum Width & Height allowed. (04 Marks)
- c. The applicable safe operating requirements for power operated watertight doors. (09 Marks)
7. As per the Marpol convention of IMO
- a. State the requirement to be fulfilled by the data recording device fitted on oily water separators on board ship as per the Marpol Annex I. (05 Marks)
- b. What is mean by "Mandatory Prewash" with reference to Marpol Annex II? (03 Marks)
- c. Briefly describe the IMO ship types as per Marpol Annex II. (06 marks)
- d. State the complete name of the Certificate issued to ship to indicate the compliance with IBC code. (02 Marks)
8. Referring to Marpol Annex VI.
- a. What is meant by "Particulate Matter" [PM]? (03 Marks)
- b. Briefly state the ways of PM enters & exists in the atmosphere. (04 Marks)
- c. State the details to be included in Shipboard Energy Efficiency Management Plan. (05 Marks)
- d. Suggest 04 steps that you could take to improve the energy efficiency of a ship. (04 Marks)

9. Polar Code has been introduced to mitigate the risks encountered to ships operating in polar waters and to protect highly sensitive sea areas in that region.
- a. State 05 hazards identified for vessels operating in polar areas. (05 Marks)
 - b. State the different ship categories define under this Code? (03 Marks)
 - c. State 04 exemptions that may be granted by the administration for existing ships operating in polar waters under polar Code? (04 Marks)
 - d. What are the basic requirements to be fulfilled to operate a ship in polar waters under this code? (04 Marks)



CINEC CAMPUS(PVT)LTD

Faculty of Marine Engineering

Department of Marine Engineering



Examination for Officer in Charge of an Engineering Watch on Ships of 750kW Propulsion Power or More

ENGINEERING KNOWLEDGE – I (GENERAL)**TIME ALLOWED - THREE HOURS**

Attempt SIX questions only as follows:

FOUR questions from Section A

ONE question from Section B

ONE question from Section C

Marks for each part of the question are shown in the brackets

Pass mark 50 % of total **AND** also need to obtain the minimum of 8 Marks in each Section B and C.

Answers with clear sketches/diagrams, neat handwriting and clear expression will get full marks.

Date: 2022.09.22

Pass marks: 50%

Section A

1.
 - a) Name the safety features incorporated in auxiliary boilers. (4 marks)
 - b) State the firefighting systems provided to protect the auxiliary boiler (2 marks)
 - c) State the actions that you would take as a watch keeping engineer if steam escape is observed through the auxiliary boiler safety valves during your watch. (6 marks)
 - d) State the types of water tests are performed on a low-pressure auxiliary boiler/economizer. (4 marks)
2.
 - a) Sketch and briefly describe the operation of a two-stage main air compressor and name the components. (6 Marks)
 - b) Explain why intercoolers are fitted in air compressors. (4 Marks)
 - c) Explain why it is necessary for air compressor to have sufficient drains fitted between each stage of compression. (3 Marks)
 - d) State which routines, attention requires for a trouble-free operation of the compressor. (3 Marks)

3.

a) Domestic cold rooms maintained at different temperature may be served by one refrigeration plant. Explain by using sketches as necessary, how different rooms temperatures are controlled.

(10 marks)

b) What are the signs of air in the system and explain how air can be removed from the system.

(4 marks)

c) Explain the effects of oil carried over from the compressor to the system.

(2 marks)

4.

With reference to centrifugal oil fuel purifiers explain:

(a) What are the reasons for purifier Overflowing.

(4 marks)

(b) What are the reasons for purifier Vibration.

(4 marks)

(c) What are the reasons if purifier is not Desludging.

(4 marks)

(d) What are the reasons for Water carried away with oil.

(4 marks)

5. a) Sketch a simple cross section through a single stage centrifugal pump with a fully shrouded single-entry impeller; name the components of the pump and indicate the direction of fluid flow.

(06 marks)

b) State causes for following troubles with centrifugal pumps

- No delivery or insufficient delivery

(02 marks)

- Discharge pressure insufficient

(02 marks)

- Lack of priming

(02 marks)

- Vibration of pump

(02 marks)

c) What is NPSH of a centrifugal pump

(02 marks)

6.

(a) Sketch and describe the coupling which is essential to withdraw propeller shaft from aft.

(6 Marks)

(b) Explain fitting and removal procedure.

(4 Marks)

(c) Where are they used onboard?

(2 Marks)

(d) What are the advantages of muff coupling?

(4 Marks)

7.

a. Sketch and describe a 4-ram hydraulic steering gear system and briefly explain safe operation.

(8 Marks)

b. What is the indication of air in the steering system

(2 Marks)

c. What is the function of a hunting gear in steering gear on a ship

(2 Marks)

d. Explain the procedure of testing the steering gear prior leaving the port.

(4 Marks)

Section B

8.

With reference to insulation testing of electrical equipment:

- (i) Discuss the purpose of insulation testing and importance of carrying out on regular basis. (5 marks)
- (ii) Describe the procedure for taking a set of insulation readings on an electric motor. (6 marks)
- (iii) Describe the precautions to be taken when testing an AC generator. (5 marks)

9.

With reference to three phase A.C. motors

- (i) what would be the limitations on direct online starting. (4 Marks)
- (ii) Describe with aid of diagram a star-delta starting (9 Marks)
- (iii) Evaluate why a motor design for delta connection winding must not be connected to run on star connection. (3 Marks)

Section C

10. With respect to trim & stability, describe the following:

- a) Effects on the center of the gravity of slack tanks. (4 marks)
- b) Effect on stability of ice formation on the superstructure. (4 marks)
- c) Effects of wind and waves on ship's stability. (4 marks)
- d) Effect of water absorption by deck cargo & retention of water on deck. (4 marks)

11. With reference to the prevention of hull corrosion briefly explain the following:

- a) Cathodic protection by sacrificial anodes (4 marks)
- b) Briefly explain protection provided by ICCP system (8 marks)
- c) State the purpose of shaft earthing system (2 marks)
- d) State the purpose of MGPS system (2 marks)

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DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA
MINISTRY OF PORTS AND SHIPPING
MERCHANT SHIPPING SECRETARIAT

Examination for Officer in Charge of an Engineering Watch on Ships of
750kW Propulsion Power or More

THERMODYNAMICS

- TIME ALLOWED - THREE HOURS
- Answer SIX questions only
- Date: 2021.....

Pass marks: 50%

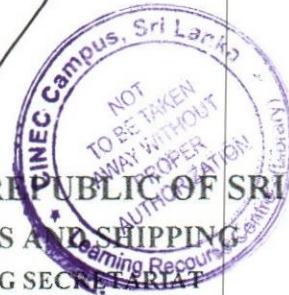
Answers with clear sketches/diagrams, neat handwriting and clear expression will get full marks

For air $c_p = 1.005 \text{ kJ/kg K}$, $c_v = 0.717 \text{ kJ/kg K}$, $\gamma = 1.4$

Composition of air (mass proportions): 77 % of Nitrogen and 23 % of Oxygen

Specific heat capacity of water 4.2 kJ/kg K , Latent heat of evaporation of water 2.256 MJ/kg

1. 1 m^3 of air at 120 kPa and 27°C is compressed adiabatically in a close system to one quarter of its original volume. The air is then cooled at constant pressure until its temperature is 27°C . The air then expanded back to its original condition.
 - a. Draw the PV diagram to represent the process on air (4 marks)
 - b. Determine
 - i. The temperature and pressure at the end of compression (4 marks)
 - ii. The volume at the end of heat rejection (4 marks)
 - iii. The work transfer during compression and constant pressure cooling (4 marks)
 - iv. The polytropic exponent of the expansion process (4 marks)
2.
 - a. A fuel composition by mass is Carbon 74%, Hydrogen 9%, Oxygen 6% and remainder incombustible. If 16 kg of air is supplied per kg of fuel, determine
 - i. The calorific value of the fuel (4 marks)
 - ii. Stoichiometric air fuel ratio (4 marks)
 - iii. The percentage of excess air supplied (4 marks)Calorific values of Carbon and Hydrogen are 33.7 MJ/kg and 144 MJ/kg respectively.
 - b. A boiler delivers 2000 kg of steam per hour at a pressure of 10 bar and with a dryness fraction of 0.8 . The feed-water to boiler is at a temperature of 80.3°C . Determine the thermal efficiency of the boiler if the fuel described under 'part a' is used for firing at the rate of 250 kg/h (8 marks)



3. In an ideal *Otto cycle* conditions at the start of compression are 0.95 bar and 20°C . The volume compression ratio is $8:1$ and the maximum pressure is 32 bar . Determine *per kg of air*.
- The heat received (5 marks)
 - The heat rejected (5 marks)
 - The cycle efficiency (5 marks)
 - The ratio of maximum to mean pressure (5 marks)
4. In an ideal *Diesel cycle* the volume compression ratio is $16:1$ and fuel admission continues for 10% of the stroke under constant pressure. The conditions of air at beginning of compression are 15°C and 1.03 bar . Determine
- Temperature and pressure at the end of compression (4 marks)
 - The maximum temperature of the cycle (4 marks)
 - The work transfer per cycle for 1 kg of air (4 marks)
 - The mean effective pressure (4 marks)
 - The cycle efficiency (4 marks)
5. A water cooled compressor driven by an engine takes in 0.08 m^3 of air per minute at 288 K and 0.95 bar and delivers it at 12 bar . The compression index is 1.25 and the mechanical efficiency of the compressor is 85% .
- Determine
 - Temperature after the compression (4 marks)
 - Indicated power of the compressor (4 marks)
 - Shaft power and friction power (4 marks)
 - Due to a partial failure of water cooling system, the compression index raises to 1.32 , find the increase in shaft power of the engine. (8 marks)
6. A six cylinder, single acting, four stroke oil engine, of 600 mm stroke and 525 mm bore runs at 5 rev/s when the mean effective pressure is 12.5 bar . The fuel consumption rate is 900 kg/h and calorific value of the fuel is 44.2 MJ/kg . If the mechanical efficiency is 85% , determine
- Indicated power (5 marks)
 - Brake power (5 marks)
 - Brake specific fuel consumption (5 marks)
 - Brake thermal efficiency (5 marks)

7. Steam is supplied to a turbine at $30 \text{ bar } 400^\circ\text{C}$ and the condenser pressure is 0.03 bar . The power developed is 300 MW when the expansion is isentropic in the turbine. There is no under cooling in the condenser and feed pump work is negligible. Determine
- The heat supplied per kg in boiler (5 marks)
 - Dryness fraction after expansion in turbine (5 marks)
 - The ideal efficiency of the Rankine cycle (5 marks)
 - The steam consumption by the turbine (5 marks)
8. A cold storage is to be made from mineral wool sandwiched between two layers of timber. The inner layer of timber will be 35 mm thick and outer layer of timber will be 40 mm thick. The refrigeration equipment available is capable of removing 45 W/m^2 of wall area. The storage is to be maintained at -20°C and an ambient temperature of 30°C . Calculate
- The minimum thickness of insulation (4 marks)
 - The inner surface temperature (4 marks)
 - The interface temperature between the inner layer of wood and insulation (4 marks)
 - The interface temperature between the outer layer of wood and insulation (4 marks)
 - The outer surface temperature (4 marks)
- Thermal conductivities of mineral wool and timber are 0.042 and 0.2 W/m K respectively. Surface transfer coefficient for inner and outer surface 14 and $8 \text{ W/m}^2 \text{ K}$ respectively.
9. In Ammonia refrigerating plant the refrigerant leaves the condenser as a saturated liquid at 10.34 bar . The evaporator pressure is 2.265 bar and the refrigerant leaves the evaporator as a vapour 0.8954 dry . If the circulation of the refrigerant through the plant is 4 kg/min ,
- Determine
 - The dryness fraction at inlet to the evaporator (3 marks)
 - Refrigerant effect per minute (3 marks)
 - Show that the refrigerant will be completely dried when it enters the condenser (4 marks)
 - Draw the T - S diagram for the cycle (4 marks)
 - Determine the compressor work done per minute and coefficient of performance of the plant (6 marks)



DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

MINISTRY OF PORTS AND SHIPPING

MERCHANT SHIPPING SECRETARIAT

Examination for Officer in Charge of an Engineering Watch on Ships of
750kW Propulsion Power or More

MATHEMATICS

• TIME ALLOWED - THREE HOURS

• Answer SIX questions only

• Date: 2021.....

Pass marks: 50%

Answers with clear sketches/diagrams, neat handwriting and clear expression will get full marks

1.
 - a. If $a = \log 2, b = \log 3$ and $c = \log 5$, find the value of $5a + 2b - 2c$ (5 marks)
 - b. Solve the equation $\log_5 x - 4 \log_x 5 - 3 = 0$ (5 marks)
 - c. Determine the partial fractions of $\frac{x^2 - 1}{(x+1)(x^2 + 1)}$ (5 marks)
 - d. Show that the function $f(x) = 3x^2 - 6x + 5$ is positive for all real values of x and find its minimum value. (5 marks)
2. A quadratic function is defined by $f(x) = x^2 - 2x - 3$.
 - a. Find the set of values of x for which $f(x) > 7$. (5 marks)
 - b. Find the value of k for which $f(x) = kx$ has identical real roots. (5 marks)
 - c. By considering the identity $x^2 - 2x - 3 = (x+A)^2 + B$, where A and B are constants, find the greatest value of $\frac{1}{f(x)}$. (5 marks)
 - d. Sketch the curve $y = f(x)$, showing any intercept with the coordinate axes. (5 marks)
3. If $Z \neq 0$ and $1 + \cos \theta - i \sin \theta = \frac{2}{Z}$, and z is a complex number and θ is in radian and $i = \sqrt{-1}$
 - a. Show that $Z = 1 + \frac{\sin \theta}{1 + \cos \theta} i$ (5 marks)
 - b. Determine $|Z|$ and $\text{Arg}(Z)$ (5 marks)
 - c. Show that $Z \cdot \bar{Z} = \frac{2}{1 + \cos \theta}$ (5 marks)
 - d. Hence, find the Z^{-1} (5 marks)



4.

- a. Solve the simultaneous equations using matrices (Gauss-Jordan method or Cramer's rule)

$$\begin{aligned}x + y + z &= 3 \\x + 2y + 3z &= 4 \\x + 4y + 9z &= 6\end{aligned}$$

(10 marks)

- b. Determine the inverse of the following matrix

$$A = \begin{pmatrix} 1 & 1 & 1 \\ 1 & 2 & 3 \\ 1 & 4 & 9 \end{pmatrix}$$

(10 marks)

5.

- a. Prove that

i. $\frac{2\cos x}{\cot x \cos x - \sin x} = \tan 2x$

(3 marks)

ii. $\sin 4\theta \cos \theta - \cos 2\theta \sin \theta = \sin 3\theta \cos 2\theta$

(3 marks)

- b. Prove that $\frac{\sin(A-B)}{\cos A \cos B} = \tan A - \tan B$ Hence show that

$$\frac{\sin(A-B)}{\cos A \cos B} + \frac{\sin(B-C)}{\cos B \cos C} + \frac{\sin(C-A)}{\cos C \cos A} = 0$$

(6 marks)

- c. Given that $\tan \theta = t$, express $3\cos \theta + 2\sin \theta$ in terms of t . Hence solve the equation $3\cos \theta + 2\sin \theta = 3$

(8 marks)

6.

- a. Differentiate the following functions with respect to x

i. $y = \frac{\sin 2x}{\sqrt{x}}$

(4 marks)

ii. $y^2 + y \cos x = 0$

(4 marks)

- b. Determine the stationary values of $y = \frac{x^2 - 2x + 1}{x + 1}$ and describe the nature of them

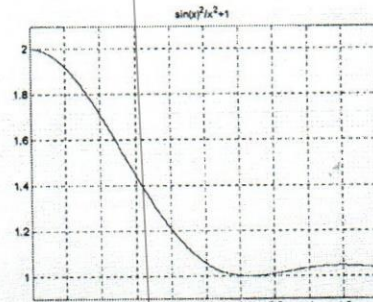
(6 marks)

- c. If $x = t + \cos t$, $y = \sin t$, estimate $\frac{dy}{dx}$ and $\frac{d^2y}{dx^2}$ when $t = \frac{\pi}{4}$

(6 marks)

7. Figure represents the function, $y = 1 + \frac{\sin^2 x}{x^2}$ in the $0 \leq x \leq 2\pi$

- a. Evaluate the area under the curve given by the integral, $\int_0^{2\pi} \left(1 + \frac{\sin^2 x}{x^2}\right) dx$ (10 marks)
- b. Find the volume generated by the solid revolution of the lamina about x-axis (10 marks)



Hint: Use the 1/3 Simpson's rule to evaluate the integrals for ten ordinates ($n = 10$)

8. Determine the integrals with respect to x

- a. $\int x^2 + \frac{1}{x} + e^{-2x} dx$ (5 marks)
- b. $\int_0^{\pi/2} \sin 2x + \sec^2 x - \operatorname{Cosec}^2 3x dx$ (5 marks)
- c. $\int \frac{x}{(x+2)(x-1)} dx$ (5 marks)
- d. $\int x \ln x dx$ (5 marks)

9.

a. Determine the partial derivatives $f_{xx}, f_{xy}, f_{yx}, f_{yy}$ for the function,

$$f(x, y) = 2x^2y + 3xy^3 \quad (8 \text{ marks})$$

b. If $u(x, y) = \ln(1 + x^2y)$, show that

i. $x \frac{\partial u}{\partial x} = 2y \frac{\partial u}{\partial y}$ (6 marks)

ii. $x^2 \frac{\partial^2 u}{\partial x \partial y} + 2 \frac{\partial^2 u}{\partial y^2} = 0$ (6 marks)

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DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

MINISTRY OF PORTS AND SHIPPING

MERCHANT SHIPPING SECRETARIAT

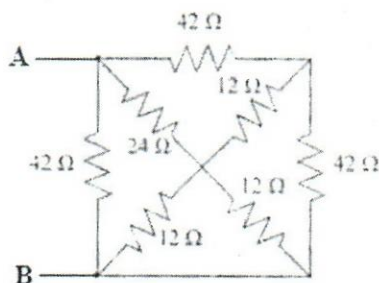
Examination for Officer in Charge of an Engineering Watch on Ships of 750kW
Propulsion Power or More

Electrotechnology

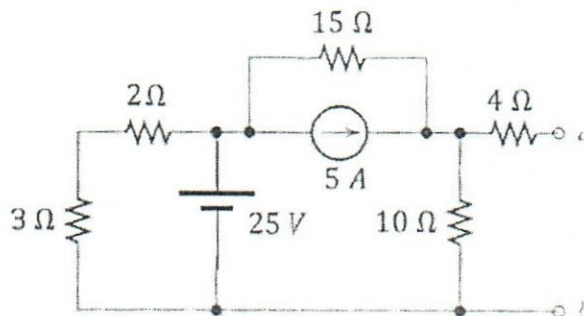
- TIME ALLOWED - THREE HOURS
 - Answer ANY FOUR questions from part A and ANY TWO questions from part B
 - Date: 2021.....
- Pass marks: 50%
- Answers with clear sketches/diagrams, neat handwriting and clear expression will get full marks

Part A

- a) State Kirchhoff's laws and Ohm's law in electricity. (6 marks)
- b) Find the total resistance between A and B. (6 marks)



- c) If internal resistance of current source is infinity and all voltage source are ideal, find the current through load resistor 6Ω when it is connected between a and b . (8 marks)

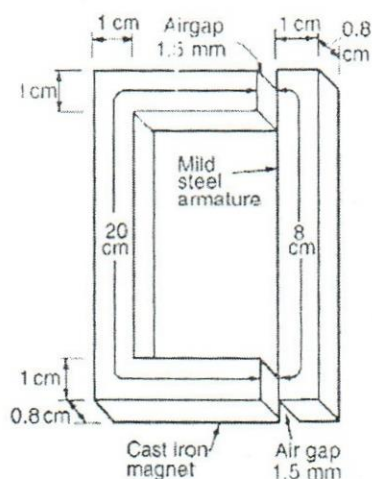


2. a) Define the term periodic time. (4 marks)
- b) Determine the periodic time for frequencies of 50Hz. (4 marks)
- c) The following three impedances are connected in parallel across a 240V, 50Hz supply:
- a resistance of $300\ \Omega$
 - a coil of inductance 130mH and $55\ \Omega$ resistance
 - a $170\ \Omega$ resistor in series with a $25\ \mu\text{F}$ capacitor.

Calculate

- i. the circuit current through each impedance (6 marks)
- ii. the total power consumption of the system. (6 marks)
3. a) What are the power stages of D.C. motor? (3 marks)
- b) Explain the behavior of D.C. motor when motor is suddenly loaded. (3 marks)
- c) A 230 V shunt motor takes a total current of 80 A and runs at 800 r.p.m. Shunt field resistance and armature resistance are $115\ \Omega$ and $0.1\ \Omega$ respectively. If iron and friction losses amount to 1000 W, find
- i. copper losses (4 marks)
- ii. efficiency (6 marks)
- iii. armature torque at 800 r.p.m. (4 marks)
4. a) State Faraday's laws of electromagnetic induction. (4 marks)
- b) Two coils A and B having turns 100 and 1000 respectively are wound side by side on a closed iron circuit of cross-sectional area $8\ \text{cm}^2$ and mean length 80 cm. The relative permeability of iron is 900.
- i. Calculate the mutual inductance between the coils. (6 marks)
- ii. What will be the induced e.m.f. in coil B if current in the coil A is increased uniformly from zero to 10 A in 0.02second? (4 marks)
- c) Two coils connected in series have a self-inductance of 20mH and 60mH respectively. The total inductance of the combination was found to be 100mH. Determine the amount of mutual inductance that exists between the two coils assuming that they are aiding each other. (6 marks)

5. a) i. Define Magnetic density (2 marks)
- ii. State Ampere's work rule in electromagnetism. (2 marks)
- b) A magnetic pole face has a rectangular section having dimensions 200 mm by 100 mm. If the total flux emerging from the pole is $150 \mu\text{Wb}$, calculate the flux density. (4 marks)
- c) Following figure shows the magnetic circuit of a relay. When each of the air gaps are 1.5 mm wide find the mmf required to produce a flux density of 0.75 T in the air gaps, if the relative permeability of the cast steel is 800 and the relative permeability of the mild steel is 550. (8 marks)



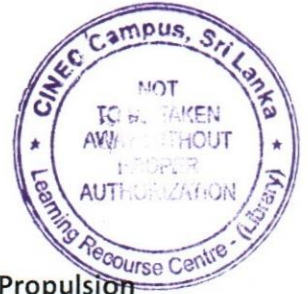
- c) Hence, find required minimum current in a coil of 1000 turns wound on the cast iron to operate relay. (4 marks)
6. a) Define power factor and express power factor improving methods (6 marks)
- b) A single phase a.c. generator supplies the power to the following loads:
- Lighting load of 500 W at unity power factor.
 - Induction motor load of 2 kW at p.f. 0.7 lagging.
 - Synchronous motor load of 5 kW at p.f. 0.9 leading.
- Calculate
- i. the total kW and kVA delivered by the generator. (7 marks)
- ii. the power factor at which it works. (7 marks)

Part B

7. a) List the routine and emergency services normally supplied by batteries in shipboard practices. (8 marks)
- b) Explain the dangers which may exist in Battery room and explain how they are overcome. (6 marks)
- c) State the ranges of Voltage and specific gravity Lead acid and alkaline batteries can be used. (6 marks).
8. a) State 3 reasons why High Voltage supply is preferable in shipboard practices. (6 marks)
- b) State what type of permits are required when working with high voltage and why. (8 marks)
- c) Explain what precautions are to be taken when working with High Voltage systems. (6 marks)
9. a) List the essential services which are supplied from Emergency generator. (10 marks)
- b) What is meant by " Cold Ironing " in shipboard practices. How it is facilitated in shipboard Practices. (10marks)



CINEC Campus (Pvt) Ltd



Examination for Officer in Charge of an Engineering Watch on Ships of 750kW Propulsion Power or More

Maritime Law

- TIME ALLOWED - THREE HOURS
- Answer Any Four questions only
- Date: 2022.09.20

Pass marks: 50%

Answers with clear sketches/diagrams, neat handwriting and clear expression will get full marks

1. International Safety Management Code requires Ship Management Companies to assess Risk from all identified Hazard to its ship, personnel and environment and establish appropriate safeguards by the management company.
 - a. Define terms "Hazard", "Risk" & "Control Measures". (06 Marks)
 - b. Identify Hazards, Risk involved, and control measures you would take during preparation for carrying out repairs to leaky Gauge Glass on Auxiliary Boiler. (10 Marks)
2. With Reference to International Maritime Organization (IMO).
 - a. What are the main objectives of International Maritime Organization (IMO)? (03 Marks)
 - b. Illustrate the basic structure of IMO. (07 Marks)
 - c. What is mean by "Contracting Government" referring to IMO conventions. (03 Marks)
 - d. What is mean by "Ratification" referring to IMO convention. (03 Marks)
3. Referring to United Nations Convention of the Law of Sea – III (UNCLOS-III), regulations for sharing ocean areas & its resources briefly explain following,
 - a. Various sea areas as define by the convention using a suitable sketch. (04 Marks)
 - b. "Port State Jurisdiction". (03 Marks)
 - c. "Flag State Jurisdiction". (03 Marks)
 - d. "Innocent Passage". (03 Marks)
 - e. "International Strait". (03 Marks)

4. With reference to SOLAS Ch-II-2,
 - a. State the various classes of bulkheads use in ship building industry. (03 Marks)
 - b. Define "Category A Machinery Space". (06 Marks)
 - c. Define "Non-Combustible Material". (03 Marks)
 - d. State the reasons for using different classes of bulkheads, when separating different compartment of the ship's structure. (04 Marks)
5. With reference to the International Load Line Convention.
 - a. What is meant by "Free Board" & "Reserve Buoyancy" of a ship? (06 Marks)
 - b. What are the 04 main types of Freeboards assigned for the cargo ships under this convention. (04 Marks)
 - c. List 06 different types of items included in "Record of Conditions of Assignment for International Load Line" for a ship. (06 Marks)
6. Referring to Marpol Annex VI;
 - a. State the certificates required to be carried on board ships. (05 Marks)
 - b. What are the other relevant documents (in addition to the certificates) required to be carried on board ships under annex VI. (05 Marks)
 - c. What is meant by "Particulate Matter" [PM]? (03 Marks)
 - d. Briefly state the ways of PM enters & exists in the atmosphere. (03 Marks)
7. Certification is an essential part for maintaining the standards in commercial shipping.
 - a. State the three main parties which are involving in ship certification. (03 Marks)
 - b. What is mean by "Statutory Certificates". (02 Marks)
 - c. What is mean by "Mandatory Certificate". (02 Marks)
 - d. State the Items/Areas covered by classification societies of a ship on certification. (05 Marks)
 - e. State 04 advantages of Harmonized System of Survey & Certification system(HSSC). (04 Marks)
8.
 - a. State the objective of introducing International Ballast Water Management convention. (02 Marks)
 - b. State the ships which are required to comply with the regulations in this convention? (02 Marks)
 - c. What are the essential documents to be carried on board ships to comply with the requirement of this convention? (04 Marks)
 - d. What are the two standards provided in Ballast Water Management convention to control discharge of ballast water into sea by ships. (08 Marks)
9. SOLAS Chapter IX - ISM code introduce to the maritime industry to implement uniform procedures in Shipboard Operations.
 - a. What is meant by "Shipboard Operation"? (03 Marks)
 - b. What is meant by "Critical equipment" or "Critical Systems" as per the above code. (05 Marks)
10. Define terms "Non-Conformity" & "Major Non-Conformity". (08 Marks)



DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

MINISTRY OF PORTS AND SHIPPING

MERCHANT SHIPPING SECRETARIAT

Examination for Officer in Charge of an Engineering Watch on Ships of 750kW
Propulsion Power or More

Applied Mechanics

- TIME ALLOWED - THREE HOURS
- Answer ANY Six questions only
- Date: 2021.....

Pass marks: 50%

Answers with clear sketches/diagrams, neat handwriting and clear expression will get full marks

Density of water – 1000 kgm^{-3} Gravitational acceleration – 9.81 ms^{-2}

Density of sea water – 1025 kgm^{-3}

1

1.1 Explain the terms; simple harmonic motion (SHM), amplitude, frequency, and period of SHM. (4 marks)

1.2 A body moves with simple harmonic motion and has a velocity of 12 m/s when the displacement is 50 mm from the origin and a velocity of 3 m/s when the displacement is 100 mm from the origin, calculate;

- a. The frequency of oscillations
- b. The amplitude of oscillations
- c. The acceleration when the displacement is 75 mm (16 marks)

2.

2.1 Friction clutch can act as a safety device, discuss. (4 Marks)

2.2 A single plate clutch with both sides effective, has outer and inner diameters 600 mm and 300 mm respectively. The maximum intensity of pressure at any point in the contact surface is not to exceed 0.25 N/mm^2 . The coefficient of friction is 0.35, determine the power transmitted by a clutch at a speed of 3500 rpm. (16 marks)

3.

3.1 Show that for two particles connected by a smooth inextensible string and through a frictionless pulley, the acceleration of the particles and tension of the strings are given by; $a = \frac{g(M-m)}{M+m}$ and $T = \frac{2mMg}{M+m}$ respectively. M and m are masses of the particles and g is the gravitational acceleration.

(6 marks)

3.2 Two particles of masses 1 kg and 3kg are attached to the ends of a long light inelastic string which passes over a fixed smooth pulley. The system is held with both particles hanging at a height of 2m above the ground, and is released from rest. In the subsequent motion the heavier particle hits the ground and does not rebound. Find the greatest height reached by the mass of 1kg.

(14 marks)

4

4.1 Explain the factors affecting "coefficient of friction" and briefly describe a simple experiment to find it.

(6 marks)

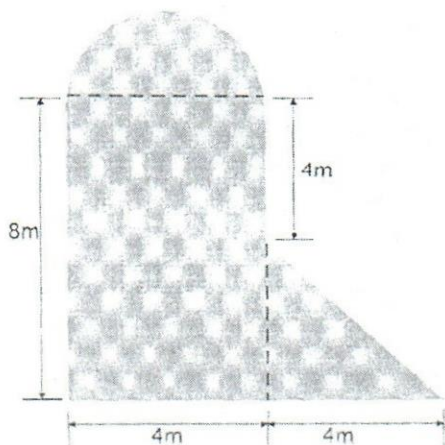
4.2 An effort of 1500N acting parallel to the plane is required to just move a certain body up an incline plane of angle 12° . If the angle of inclination is increased to 15° , then the effort required is 1728N. Find;

- The weight of the body
- Coefficient of friction.

(14 marks)

5.

5.1 Below shows a shape made-out from thin metal sheet. Find the coordinate (x, y) of the center of gravity of the given shape. Clearly indicate the x and y axes selected in your diagram. (Hint: the center of gravity of a semi-circle is at a distance of $\frac{4r}{3\pi}$ from its base measured along the radius) (20 marks)



6.

6.1 State Lami's theorem using suitable figure and notations.

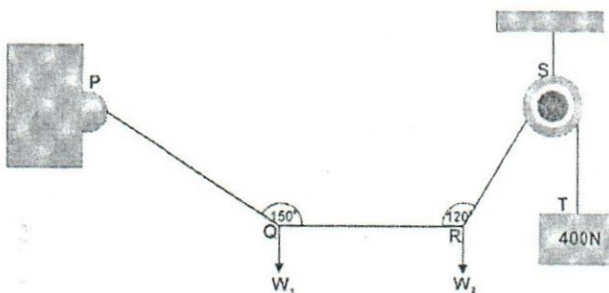
(4 Marks)

6.2 A light string PQRS whose extremity P is fixed, has weights W_1 and W_2 attached to it at Q and R. It passes round a small smooth peg at S carrying a weight of 400N at the free end T as shown in the figure. If in the equilibrium position, QR is horizontal and PQ and RS make 150° and 120° with QR respectively, find;

- Tensions in the portions PQ, QR, RS of the string
- Magnitudes of W_1 and W_2

(8 Marks)

(8 Marks)



7.

7.1 A cubical block rests on an inclined plane of $\mu = 1/\sqrt{3}$, determine the angle of inclination when the block just slides down the inclined plane

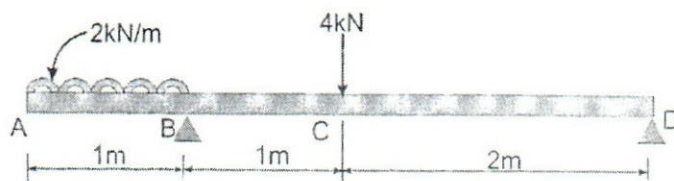
(6 Marks)

7.2 A uniform ladder of 4m length rests against a vertical wall with which it makes an angle of 45° . The coefficient of friction between the ladder and the wall is 0.4 and that between ladder and the floor is 0.5. If a man, whose weight is half of that of the ladder, climbs it, how high will it be when the ladder slips?

(14 Marks)

8.

8.1 A beam ABCD is overhanging by 1m and carries load as shown in the figure below. Draw the shear force and bending moment diagrams for the beam and locate the point of *contraflexure*. (20 Marks)



9.

9.1 State Bernoulli equation and identify the variables

(4 marks)

9.2 A Smooth pipe has two ends as A and B. The diameter at A is 20 cm and located at a height of 150 cm above the reference line. The pressure observed at the end A is 35 kPa. Pipe diameter at the end B is 30cm and it is at an elevation of 130 cm above the reference. Further the volume flow rate through the pipe is noted to be $6 \text{ m}^3/\text{s}$. If the total head loss between section A and B is equal to 4 m, find the value of pressure at B when the flow is from A to B.

(16 marks)

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DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA
MINISTRY OF PORTS AND SHIPPING
MERCHANT SHIPPING SECRETARIAT

Examination for Officer in Charge of an Engineering Watch on Ships of 750kW Propulsion Power or More

NAVAL ARCHITECTURE AND SHIP CONSTRUCTION

- TIME ALLOWED - THREE HOURS
 - Answer ANY FOUR (04) questions from Part A and ANY TWO (02) questions from Part B
 - Date: 2021.....
- Pass marks: 50%

Part A: NAVAL ARCHITECTURE

1. The half ordinates of water plane at 6.4m draft of an 11750 tonne displacement vessel when floating in seawater density of 1.026 are as follows. The Block Coefficient (C_b) of the vessel is 0.80.

| Section | AP | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | FP |
|----------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|
| $\frac{1}{2}$ Ordinates(m) | 2.5 | 3.6 | 5.8 | 7.2 | 7.8 | 8.6 | 8.0 | 7.4 | 6.0 | 2.5 | 0 |

- Calculate the area of the water plan of the vessel at this draft. (08 Marks)
 - Find the longitudinal center of floatation (LCF) at this draft. (08 Marks)
- 2.
- State why Inclining Experiment is required to carry out on newly build ships. (02 Marks)
 - List down 05 important factors to be checked when preparing a vessel for above and 03 conditions to be observed during the experiment. (04 Marks)
 - The assumed initial metacentric height of a ship of 8000 tonne light weight displacement is 1.2 m. The vessel is being prepared for inclining experiment and it is required minimum of 150 mm deflection on a 06 m long plumb line to comply with the statutory requirement. Find the minimum mass to be selected for the experiment to meet above condition, if the maximum distance that the mass could shift across the vessel is 16m. (10 Marks)

- 3.
- a. Explain following terms with reference to transvers stability of a ship.
 - i. "Transvers Metacenter" (03 Marks)
 - ii. "Free Surface Effect". (03 Marks)
 - b. Vertical center of gravity of a vessel 5000 tonnes light ship displacement is 3.5 m.

The vessel is now loaded as follow;

3500 tonnes of cargo at VCG 6.00 m above the keel

3000 tonnes of cargo at VCG 8.50 m above the keel

After loading operation 500 tonnes of seawater ballast has been taken into two(02) double bottom tanks having VCG 1.25 m above the keel to adjust required metacentric height before commencing the voyage .

At 12000 tonne displacement second (2^{nd}) moment of area of the water plane about the longitudinal center line of the vessel is $54 \times 10^3 \text{ m}^4$ & center of buoyancy is 3.2 m above the keel.

The ship's Ballast water is carried in two identical DB tanks located Port & Starboard of the vessel's longitudinal center line bulkhead and each tank is having length X Breadth; 30 m X 12 m.

Calculate the Metacentric height (GM) of the vessel;

- i. If both ballast tanks are pressed up to the tank top after above ballasting operation. (05 Marks)
 - ii. If both ballast tanks are partially filled after above ballasting operation. (05 Marks)
4. A ship of 130 m long floating at 3000 tonne displacement with 3.24m LCG aft of mid-ship.

Following mass changes taken place at port operation:

4000 tonne of Cargo loaded @ LCG 5.20 m forward of midship

1500 tonnes of Cargo discharged @ 3.43 m forward of midship

200 tonne of fuel loaded @ LCG 36.00 m aft of mid-ship

35 tonne of Fresh water loaded @ 34.60 m aft of mid-ship

5 tonne of stores loaded @ 36.00 m forward of mid-ship

Following hydrostatic particulars available in the vessel's stability booklet.

| Mean Draft-m | Displacement - tonne | MCT 1 cm - tonne m | LCB from mid- ship m | LCF from mid- ship m |
|--------------|-------------------------|-----------------------|-------------------------|-------------------------|
| 6.50 | 5740 | 47.05 | 0.60 F | 3.50 A |

Calculate the final end drafts of the vessel.

(16 Marks)

- 5.
- Name the two main components of resistance overcome by a ship when advancing through the water. (01 Marks)
 - List the factors effecting the magnitude of each of above component. (05 Marks)
 - Wetted surface area of 5.0 m model ship is 7.5 m² and during model test, towed in Sea water at 3.5 knots, indicated 48 N tension on tow rope.

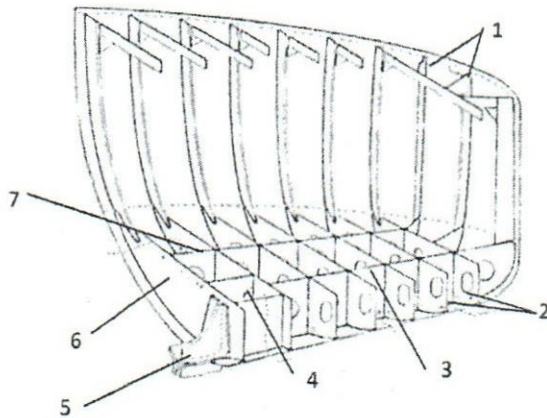
If the "Ship correlation Factor" (SCF) is 1.15, Calculate the effective power of a ship, 150m long, at its corresponding speed. (10 Marks)

$$f = 0.417 + \frac{0.773}{L+2.862} \quad \text{and} \quad R_f = f S V^n \quad n = 1.825 \quad \text{when value of } V \text{ is in Knots.}$$

- 6.
- Define following terms with respect to marine propellers;
 - Theoretical Speed (Vt) (02 Marks)
 - Wake Fraction (w) (02 Marks)
 - Speed of Advance (Va) (02 Marks)
 - Real Slip (02 Marks)
 - The diameter & the pitch ratio of a propeller fitted on 130 m long, 18,000 tonne displacement vessel is 6.0 m & 0.8 respectively. The beam of the vessel is 12.0 m and propeller rotates at 120 RPM at 8.0 m design draft when main engine operates at MCR in 1.025 tonne/m³ seawater density. The wake fraction $w = 0.5C_b - 0.05$ and the real slip is found 32 %. Calculate;
 - Speed of advance (04 Marks)
 - The speed of the ship (02 Marks)
 - Apparent slip (02 Marks)

Part B: SHIP CONSTRUCTION

7. (a) Identify the component numbered from 1 to 7 of an aft end construction of a ship shown below. (04 Marks)



- (b) Briefly Explain the function of any six components stated in above part 'a' (12 Marks)

- 8.
- a. Briefly explain the construction of un balanced rudder with an aid of a sketch (10 Marks)
 - b. with respect to marine propellers describe following terms using sketches where necessary
 - i. Pitch (02 Marks)
 - ii. Boss or hub (02 Marks)
 - iii. Back (02 Marks)
- 9.
- a. Give 4 functions of transverse water tight bulkheads. (02 Marks)
 - b. Describe, with an aid of a sketch, how an electric cable is passed through a water tight bulk head. (04 Marks)
 - c. Sketch and describe corrugated water tight bulkhead showing all strengthen members (10 marks)



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Examination for Officer in Charge of an Engineering Watch on Ships of 750kW Propulsion Power or More

Marine Engineering Drawing and Design

- TIME ALLOWED - FOUR HOURS
- Answer ALL questions

Date: 2022.09.21

Pass marks: 50%

Answers with clear sketches/diagrams, neat handwriting and clear expression will get full marks

The figure shows details of a Crane Hook.

Draw the following views of the assembled Crane Hook in First Angle Projection method.

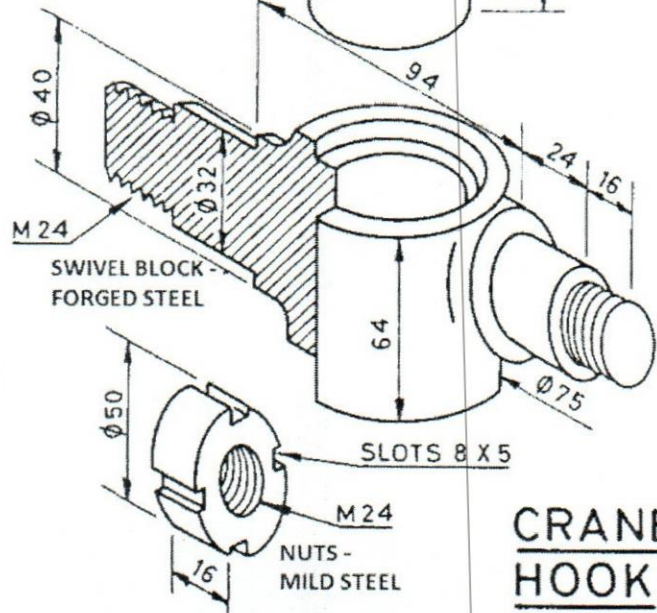
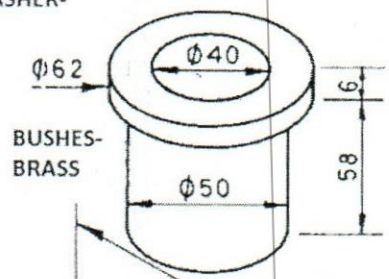
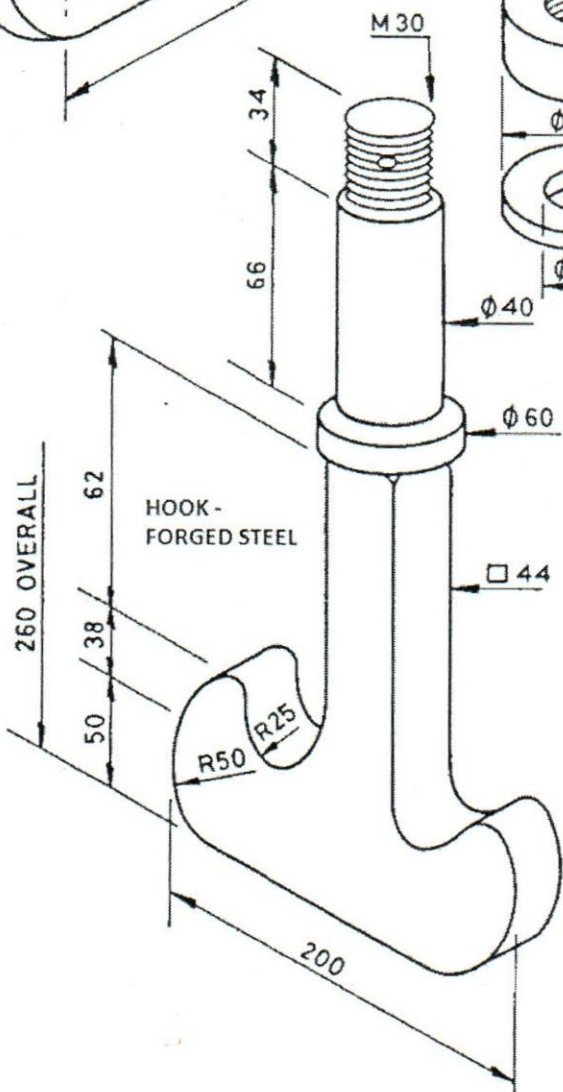
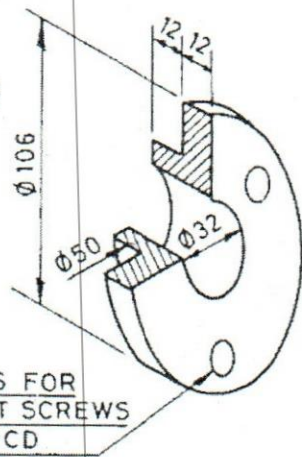
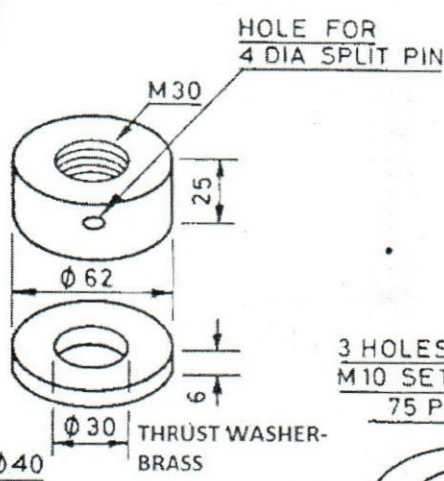
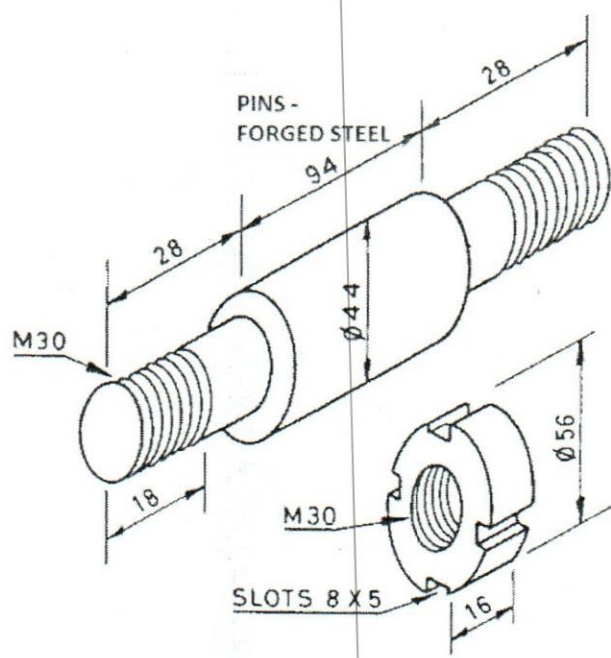
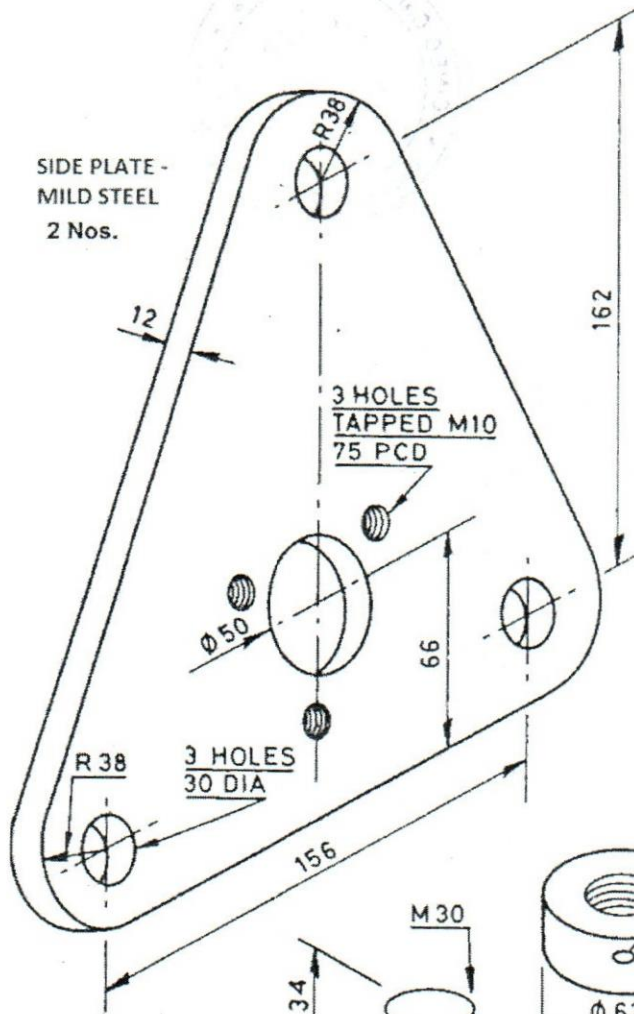
- Sectional Elevation through the vertical plane passing through the horizontal axis of the Swivel block showing all parts assembled.
- End Elevation projected to the right of (a)

Suitable dimensions should be estimated where not provided. Hidden detail is not required in any view.

Complete the drawing by including the title, projection symbol, dimensions and a list of materials of parts.

Marking System

- | | |
|---|------------|
| (a) Assembling accuracy of view (a) | (45 marks) |
| (b) Assembling accuracy of view (b) | (30 marks) |
| (c) Optimization of space | (05 marks) |
| (d) Dimensioning | (05 marks) |
| (e) List of materials of parts | (05 marks) |
| (f) Title block, projection symbol, lettering | (05 marks) |
| (g) Final appearance, neatness | (05 marks) |



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Examination for Officer in Charge of an Engineering Watch on Ships of 750kW Propulsion Power or More

NAVAL ARCHITECTURE AND SHIP CONSTRUCTION

- TIME ALLOWED - THREE HOURS
 - Answer ANY FOUR (04) questions from Part A and ANY TWO (02) questions from Part B
 - Date: 2022.09.12
- Pass marks: 50%

Part A

Q1. (a) Explain Simpson's First rule (04 marks)

(b) A ship 80 m long has equally spaced immersed cross-sectional areas as follows,

| | | | | | | | | | | | |
|------------------------|---|------|----|------|----|----|------|----|------|------|----|
| Section | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Area (m ²) | 0 | 11.5 | 27 | 38.5 | 44 | 45 | 44.5 | 39 | 26.5 | 14.5 | 0 |

(i) Calculate the displacement of the vessel in sea water of density 1025 kg/m³ (09 marks)

(ii) Prismatic coefficient (03 marks)

Q2. Explain Fresh water allowance (04 marks)

(i) Derive an equation to calculate Fresh water Allowance (FWA), with relevant to Tonnes Per Centimeter (TPC) and Displacement of the vessel (04 marks)

(ii) A ship loaded in a sea port and heading to a river port. 215 tonnes of fuel oil and stores are consumed in the ship before passing from sea water of 1.026 t/m³ into river water of 1.002 t/m³. If the mean draught remains unchanged, calculate the displacement in the river water (08 marks)

Q3. (a) Explain the terms (i) Trimming moment (ii) TPC (iii) MCT1cm (2 Marks each)

(b) A ship 120m long floats at draughts of 5.5m forward and 5.8m aft; MCT1cm 80 tonne. TPC 13, LCF 2.5m forward of midship. Calculate the new draughts when a mass of 110tonne is added 24m aft of midship. (10marks)

Q4. A vessel of constant rectangular cross-section is 60 m long 12 m beam and floats at a draught of 4.5 m. It has a mid-length compartment 9m long which extends right across the ship and up to the deck, but is sub divided by a horizontal water-tight flat 3 m above the keel.

Find the new draught if this compartment is bilged:

- (a) Below the flat (08 Marks)
- (b) Above the flat. (08 Marks)

Q5 . a. Define the following terms. You may use suitable sketches where necessary.

- (i) Block coefficient
- (ii) Water plane area coefficient
- (iii) Mid-ship section area coefficient
- (iv) Prismatic coefficient. (2 marks each)

b. A ship 150m long and 20.5m beam floats at a draught of 8m and displaces 19500 tonne. The TPC 26.5 and midship area coefficient 0.94

Calculate the block, prismatic and waterplane area coefficients.

(08 mark)

Q 6.

With regards to a ship's propeller, explain the following terms

- a.
- i. Pitch ratio (01 Marks)
- ii. Blade area ratio (BAR) (01 Marks)
- b. A propeller has a Pitch Ratio of 0.95. When turning at 2 rev/sec the real slip is 30%, the wake fraction 0.29 and the ship speed 16 knots. The thrust is found to be 400kN, the torque 270kN and QPC 0.68

Considering there is no transmission loss, (Shaft power=Delivered power)

Calculate

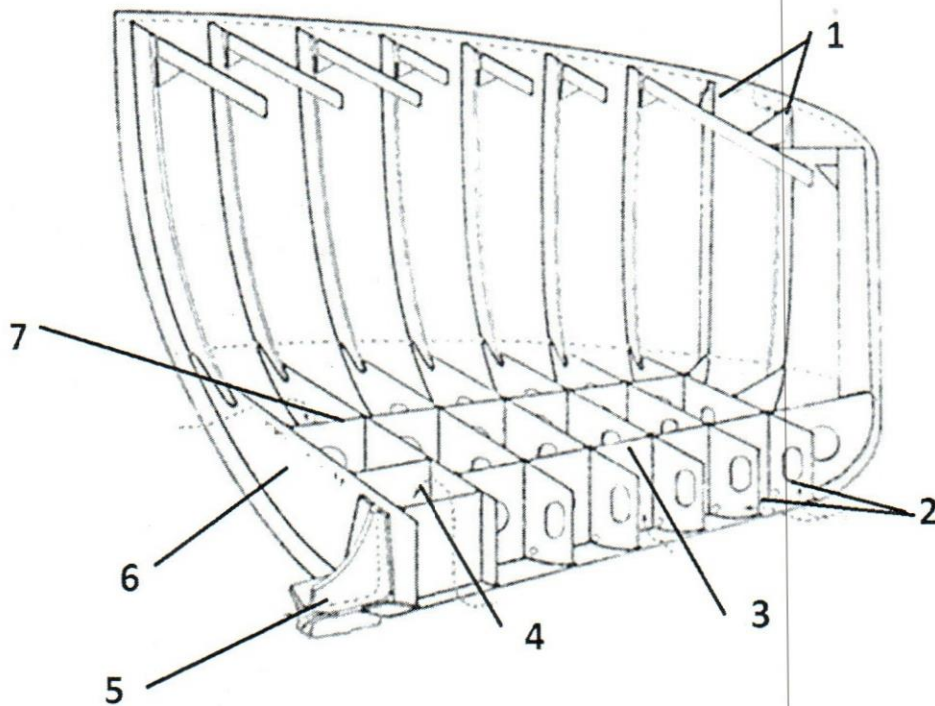
- (i) The propeller diameter (04 Marks)
- (ii) The shaft power (03 Marks)
- (iii) The propeller efficiency (03 Marks)
- (iv) The thrust deduction factor (04 Marks)

Part B**Q.7**

- a. What are the six (06) dynamic forces acting on the ship's hull girder? (06 Marks)
- b. State various kinds of localized forces are acting on hull structure with the location of the hull. (04 Marks)
- c. Identify the ship's structural components designed to withstand those localized forces using simple sketches. (09 Marks)

Q.8

- a. Identify the component numbered from 1 to 7 of an aft end construction of a ship shown below. (04 Marks)
- b. Briefly Explain the function of any six components stated in above part 'a' (12 Marks)

**Q.9**

- a. With the use of suitable sketch, Identify followings of a Marine Propeller,
- I. Face (01 Marks)
 - II. Back (01 Marks)
 - III. Leading Edge (01 Marks)
 - IV. Trailing Edge (01 Marks)
 - V. Hub (01 Marks)
 - VI. Rake (01 Marks)
- b. Briefly explain how the propeller convert torque in to thrust. (05 Marks)
- c. State the kinds of defects that you could find on the propellers when the vessel is in drydock. (05 Marks)

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Examination for Officer in Charge of an Engineering Watch on Ships of 750kW Propulsion Power or More

Thermodynamics

- TIME ALLOWED - THREE HOURS
- Answer ANY SIX Questions
- Date: 2022.05.19

Pass marks: 50%

Answers with clear sketches/diagrams, neat handwriting and clear expression will get full marks

For air $c_p = 1.005 \text{ kJ/kg K}$, $c_v = 0.717 \text{ kJ/kg K}$, $\gamma = 1.4$

Composition of air (mass proportions): 77 % of Nitrogen and 23 % of Oxygen

Specific heat capacity of water 4.2 kJ/kg K , Latent heat of evaporation of water 2.256 MJ/kg

1. In a fresh water generator, the generator shell of 1.5 m^3 capacity contains saturated water vapour and air at 40°C and vacuum pressure of 670 mmHg . Due to air leakage into the vessel, the vacuum pressure falls to 572.5 mm Hg and the temperature to 36°C . Estimate the followings
 - a. The initial partial pressure of steam and air (5 marks)
 - b. Initial mass of air in the generator shell (5 marks)
 - c. The final partial pressure of steam and air (5 marks)
 - d. The mass that has of air leaked into the generator shell (5 marks)

Assume that the atmospheric pressure reading is 760 mmHg and $1 \text{ bar} = 750 \text{ mmHg}$

2. A side wall of reefer container consists with 1.2 mm thick stainless steel sheet for outer cladding and 0.7 mm thick Aluminum sheet for inner lining. The gap between the outer cladding and inner lining is filled with Polyurethane of $0.4 \text{ W/m}^2 \text{ K}$. If the ambient temperature is 35°C and the inside temperature is -15°C . Estimate
 - a. The overall heat transfer coefficient (4 marks)
 - b. The heat transfer per hour from unit area of the side wall (6 marks)
 - c. The temperature difference across the each material of the wall (10 marks)

Thermal conductivities of Stainless steel and Aluminum are 14.4 and 237 W/m K respectively.

3. The pressure and temperature at the beginning of the compression of *Otto cycle* are **1.013 bar** and **27 °C** respectively. The maximum temperature of the cycle is **960 °C**. The isentropic compression ratio of the cycle is **6.5:1**. The cycle is repeated **3000 times/min**. Determine for the cycle
- Pressure and temperature** of each cardinal point of the cycle (6 marks)
 - The **thermal efficiency** (4 marks)
 - The **mean effective pressure** (4 marks)
 - The **theoretical output in kilowatts** (4 marks)
 - The **Carnot efficiency** within the same temperature limits (2 marks)
4. At the beginning of the compression of an ideal Dual combustion cycle the pressure and temperature of the gas are **95 kPa** and **20 °C**, respectively. The volume ratio of the compression is **16 : 1**. The heat added during the constant volume process is **240 kJ/kg** of gas. The change of volume during the constant pressure process is for **4 %** of the expansion stroke. Determine
- The pressure and temperature at the end of compression (4 marks)
 - The pressure and temperature at the end of the constant volume heating (4 marks)
 - The temperature at the end of the constant pressure heating (6 marks)
 - The efficiency of the cycle (6 marks)
5. In an air compressor, air is compressed according to the law $PV^{1.25} = \text{constant}$. The initial conditions of the air is **1.0 bar**, and **27 °C**. The compressor has a bore of **200 mm** and the stroke of **250 mm**. the clearance volume is **4 %** of the swept volume. If the final pressure is **10 bar**,
- Draw the PV diagram representing all the processes (2 marks)
 - calculate
 - For what length of the stroke air is delivered (5 marks)
 - The volume of air delivered per stroke (4 marks)
 - The final temperature and change of internal energy after the compression (4 marks)
 - The volumetric efficiency (5 marks)
- 6.
- Draw a **T-s diagram** for a vapour representing saturated liquid line, wet vapour region, dry vapour line, super heated vapour region and the critical point (6 marks)
 - A rigid container of **0.8 m³** capacity contains steam at **4 bar** and **250 °C**. The vessel is cooled until the pressure is reduced to **2 bar** under constant volume. Calculate.

- i. The mass of steam in the vessel (3 marks)
- ii. The final dryness of the steam (3 marks)
- iii. The enthalpy change (4 marks)
- iv. The entropy change (4 marks)
7. A steam power plant which operates on an ideal Rankine cycle and has a net power output of **330 MW**. Steam enters the turbine at **5 MPa** and **450 °C** and is cooled in the condenser at a pressure of **50 kPa** by running sea water at **25 °C** through the tubes of the condenser and the exit temperature is at **45 °C**.
- a. Draw the *T-S* diagram to represent processes in the cycle (4 marks)
- b. Determine
- i. The condition of the steam after the expansion in the turbine (4 marks)
- ii. The thermal efficiency of the cycle (4 marks)
- iii. The mass flow rate of the steam (4 marks)
- iv. The mass flow rate of the cooling water (4 marks)
8. A test on a seven-cylinder, 2 stroke engine resulted in the following data: average brake torque per cylinder is **148 kNm**. The engine has a bore of **600 mm** and stroke of **2050 mm** and the mechanical efficiency is **72 %**. At a full load speed of **104 rev/min**, The engine uses **1900 kg** of fuel per hour and calorific value of fuel is **40.3 MJ/kg**.
- Estimate
- a. The brake power, indicated power, and friction power per cylinder (6 marks)
- b. The indicated mean effective pressure (6 marks)
- c. Brake specific fuel consumption and indicated specific fuel consumption (4 marks)
- d. Indicated thermal efficiency and brake thermal efficiency (4 marks)
9. **Refrigerant -134a** uses to operate a reefer container in the temperature range of **-15 °C** and **35 °C**. The refrigerant enters the condenser as dry saturated vapour and leaves the condenser as a saturated liquid at **35 °C**.
- a. Draw the *T-S* diagram for the refrigeration process. (4 marks)
- b. Estimate the followings
- i. The dryness fraction of the refrigerant at the entrance and exit of the evaporator. (4 marks)
- ii. Refrigerant effect per kg (4 marks)
- iii. The coefficient of performance (4 marks)
- iv. The refrigerant flow rate if the cooling capacity is **3.6 kW** (4 marks)



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Examination for Officer in Charge of an Engineering Watch on Ships of 750kW Propulsion Power or More

Mathematics

- TIME ALLOWED - THREE HOURS
- Answer ANY SIX Questions
- Date: 2022.09.18

Pass marks: 50%

Answers with clear sketches/diagrams, neat handwriting and clear expression will get full marks

1.

- a. Divide $2x^3 + 10x^2 - 2x - 1$ by $2x + 1$, and hence find the quotient and remainder. (6 marks)
- b. Solve the equation $\log_5 x - 4 \log_x 5 - 3 = 0$ (6 marks)
- c. Express in partial fractions $\frac{x^2 + 2x - 3}{(x^2 + 2)(x - 1)^2}$ (8 marks)

2.

- a. Prove that $\frac{1 - \cos x}{\sin x} = \tan \frac{x}{2}$ (5 marks)
- b. Find the possible values of $\tan \frac{\theta}{2}$ if $\tan \theta = \frac{5}{12}$ (Hint: $\tan 2A = \frac{2 \tan A}{1 - \tan^2 A}$) (5 marks)
- c. Find the general solution of the equation $\cos \left(\theta + \frac{\pi}{3} \right) = \frac{\sqrt{3}}{2}$ (5 marks)
- d. A 15 m high mast is placed on top of a cliff whose height above sea level is unknown. An observer as sea level sees the top of the mast at an elevation of $46^\circ 40'$ and the foot of the mast at $39^\circ 24'$. Estimate the height of the cliff. (5 marks)

3.

a. If $z_1 = \sqrt{2} \angle \frac{\pi}{4}$, $z_2 = 6 \angle \frac{\pi}{3}$ and $z_3 = 2 \angle \frac{\pi}{6}$, find

a. $z_1 + 2z_2 - z_3$

b. $2z_2 \times (3z_1 - z_3)$

c. $\frac{2z_1 - iz_3}{z_2 - z_1}$

(12 marks)

Hint: $r \angle \theta \equiv r(\cos \theta + i \sin \theta)$

b. Find the square root of $2 + i$

(8 marks)

4.

e. Prove that $\cot \frac{\theta}{2} - 2 \cot \theta = \tan \frac{\theta}{2}$

(5 marks)

f. Find the possible values of $\cos \frac{\theta}{2}$ if $\tan \theta = \frac{5}{12}$ (Hint: Use the double angle formulae)

(5 marks)

g. Find the general solution of the equation

i. $\sin\left(\theta + \frac{\pi}{3}\right) = \frac{\sqrt{3}}{2}$

(5 marks)

ii. $\cos^2 \theta - \sqrt{3} \sin \theta \cos \theta = 0$

(5 marks)

5.

a. Differentiate the following function with respect to x

i. $y = \frac{1}{6}x^{-3} + \frac{2}{x} + \frac{2x^6}{3} - 5x + 6$

(4 marks)

ii. $y = \frac{x^2 + 1}{(x^3 - 2)}$

(4 marks)

b. A curve is given, parametrically, by

$$x = t - \sin\left(\frac{\pi t}{2}\right), \quad y = \cos\left(\frac{\pi t}{2}\right) - t^2$$

Find the x - and y - coordinates of the point P which corresponds to the parameter $t = 2$ and find the value of $\frac{dy}{dx}$ and $\frac{d^2y}{dx^2}$ at P . (12 marks)

6.

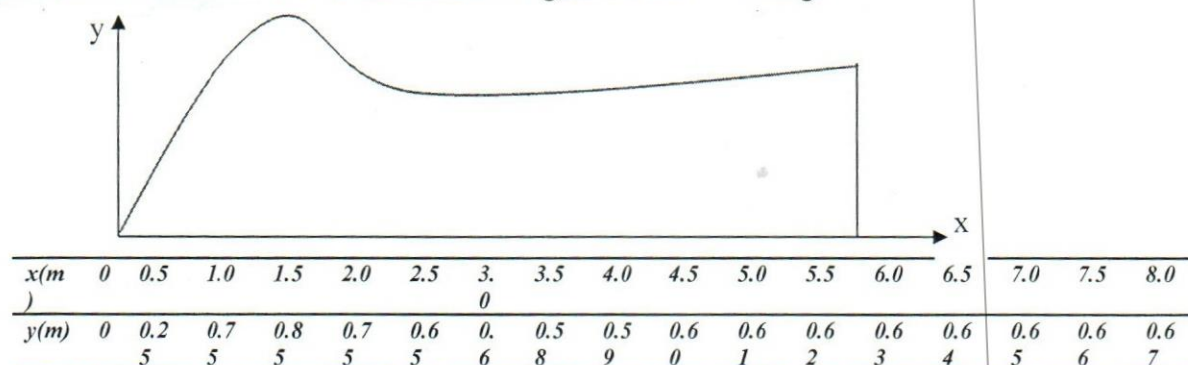
a. Evaluate

a. (i) $\int \left(2x + \frac{1}{x}\right)^2 dx$ (ii) $\int \sin^2 x dx$ (iii) $\int \frac{x+1}{x^2-2x-15} dx$ (9 marks)

b. Find the area of the region, R bounded by $y = x^2 - 4x + 6$ and $y = 2x + 6$. (6 marks)

c. If R is rotated around x axis by a complete angle, find the volume of the solid generated. (5 marks)

7. An open topped fuel tank with rectangular side figure represents a lamina made by coordinates given in the table below. Use the table and figure for the followings



- a. Calculate the area of the figure using Simpson's 1/3 rd rule (5 marks)
- b. Determine the center of mass about the x -axis (Hint: use the Simpson's rule to find the integration) (10 marks)
- c. Hence find the volume generated by the lamina about x -axis by a half of a revolution (Hint: Use the Pappus' theorem) (5 marks)

8. A tank has a square base of side x meters. The tank is made by a metal plate and its surface area is 200 m^2 .

- i. Write an expression for volume of the tank in terms of x (4 marks)
- ii. Using differential calculus, calculate the value of x such that the volume of the tank is a maximum (8 marks)
- iii. Calculate the maximum volume of the tank (4 marks)
- iv. The tank is filled with the rate of $20 - 3t \text{ m}^3/\text{s}$ find the time taken to fill the maximum volume of the tank (4 marks)

9.

a. If $A = \begin{pmatrix} 1 & 3 \\ 2 & -2 \end{pmatrix}$ and $B = \begin{pmatrix} -1 & 3 \\ 2 & 1 \end{pmatrix}$,

- i. Find products of AB and BA (4 marks)
- ii. Find the inverses of AB and BA products (4 marks)

b. Solve the simultaneous equations of

$$x - y + z = 4$$

$$x - 2y + 3z = 1$$

$$2x + y - 3z = 4$$

(12 marks)



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Examination for Officer in Charge of an Engineering Watch on Ships of 750kW Propulsion Power or More

Electrotechnology

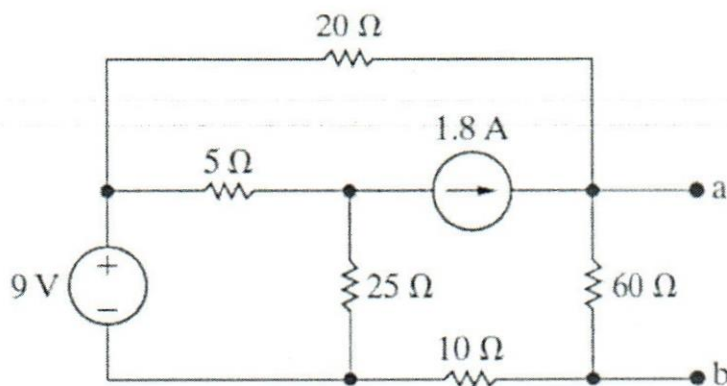
- TIME ALLOWED - THREE HOURS
 - Answer ANY FOUR questions from part A and ANY TWO questions from part B
 - Date: 2022.09.17 Pass marks: 50%
- Answers with clear sketches/diagrams, neat handwriting and clear expression will get full marks

Part A

- Define the term periodic time. (4 marks)
 - Determine the periodic time for frequencies of 50Hz. (4 marks)
 - The following three impedances are connected in series across a 40V, 20kHz supply:
 - a resistance of $3\ \Omega$
 - a coil of inductance $130\ \mu\text{H}$ and $5\ \Omega$ resistance
 - a $10\ \Omega$ resistor in series with a $0.25\ \mu\text{F}$ capacitor.

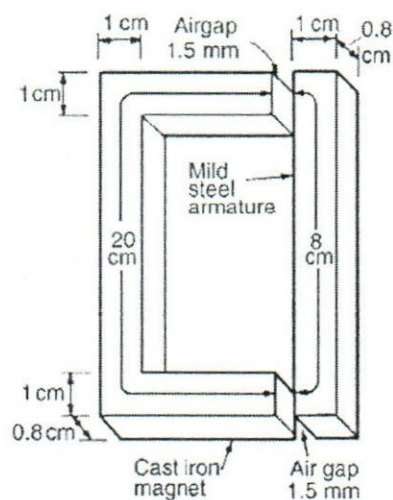
Calculate

 - the circuit current (4 marks)
 - the circuit phase angle and (4 marks)
 - the voltage drops across each impedance. (4 marks)
- State Kirchhoff's laws in electricity. (6 marks)
 - Find the Thevenin equivalent with respect to the terminal a and b for the circuit in below by finding the open-circuit voltage and the short-circuit current. (10 marks)



- Hence, find the current through $10\ \Omega$ load resistor which is connected a and b. (4 marks)

3. A 220 V shunt motor takes a total current of 80 A and runs at 800 r.p.m. Shunt field resistance and armature resistance are 50Ω and 0.1Ω respectively. If iron and friction losses amount to 1600 W, find
- copper losses (6 marks)
 - efficiency (8 marks)
 - armature and shaft torque at 800 r.p.m. (6 marks)
4. a) State Faraday's laws of electromagnetic induction. (4 marks)
- b) A flux of $400 \mu\text{Wb}$ passing through a 150-turn coil is reversed in 40 ms. Find the average e.m.f. induced. (4 marks)
- c) Two coils A and B having turns 100 and 1000 respectively are wound side by side on a closed iron circuit of cross-sectional area 8 cm^2 and mean length 80 cm. The relative permeability of iron is 900. Calculate
- Calculate the mutual inductance between the coils. (6 marks)
 - What will be the induced e.m.f. in coil B if current in the coil A is increased uniformly from zero to 10 A in 0.02 second? (6 marks)
5. a) Define Magnetic intensity (4 marks)
- b) Following figure shows the magnetic circuit of a relay. When each of the air gaps are 1.5 mm wide find the mmf required to produce a flux density of 0.75 T in the air gaps, if the relative permeability of the cast steel is 800 and the relative permeability of the mild steel is 550. (12 marks)



- c) Hence, find required minimum current in a coil of 1000 turns wound on the cast iron to operate relay. (4 marks)

6. a) A capacitor, an electric resistance heater and an impedance are connected in parallel to 120V, 60Hz system. The capacitor draws 50VAR, the heater draws 100W and the impedance draws 269 VA at a power factor 0.74 lagging. Calculate
- i. the system active power (4 marks)
 - ii. the system reactive power (4 marks)
 - iii. the system power factor (3 marks)
- b) A 230V, 50Hz single phase motor takes 70A and operates at a power factor 0.75 lagging. If a capacitor of 160 μ F is connected in parallel with the motor. Find the new current and new power factor. (6 marks)
- c) What are the power factor improvement methods in power systems. (3 marks)

Part B

7. a) Explain under what conditions fuses can be used and they cannot be used for the protection of Electrical distribution systems. (10 marks)
- b) Explain in detail why Reverse power protection is required when Alternators are load sharing. (10 marks)
8. a) With regards to Alternator's state two methods how excitation of the rotor is provided, Explain one method in detail. (10 marks)
- b) Explain what protection devices are fitted to alternators against faulty conditions and explain one in detail. (10 marks)
9. a) State 3 reasons why high voltage installations are used onboard ships. (6 marks)
- b) Explain how high voltage electrical equipment can be released for maintenance. State what permits need to be done. (8 marks)
- c) State what precautions are need to be carried out when working in High Voltage components. (6 marks)



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Examination for Officer in Charge of an Engineering Watch on Ships of 750kW Propulsion Power or More

Applied Mechanics

- TIME ALLOWED - THREE HOURS
- Answer ANY SIX Questions
- Date: 2022.09.16

Pass marks: 50%

Answers with clear sketches/diagrams, neat handwriting and clear expression will get full marks

Density of water – 1000 kgm^{-3} Gravitational acceleration – 9.81 ms^{-2}

Density of sea water – 1025 kgm^{-3}

1.

1.1 Describe briefly the advantages and disadvantages of using belt drives for power transmission compared to other engineering methods (4 marks)

1.2 Open belt drive consists of a V-belt with groove angle of 50° . The drive pulley runs at a speed of 650rpm having diameter of 500mm. The angle of contact at the pulley surface is 180° and coefficient of friction between belt and pulley is equal to 0.25. The tension set at pulley when it is not running is equal to 3500N. Determine the power transmission of belts, when pulley has three belts mounted on it. (16 marks)

2.

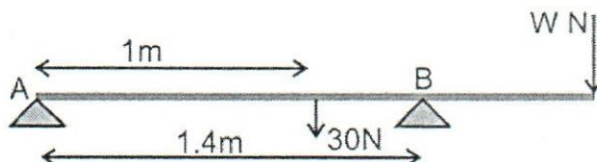
2.1 Clearly write three newton laws and derive $F=ma$ from the second law. (4 marks)

2.2 A vehicle of mass 2 tons has a frictional resistance of 50N/ton and running down a slope (1 in 80 inclination) with no engine force. As one instant the speed of the vehicle at the top of the incline plane was observed to be 36km/h. Find the speed of the vehicle in km/h running down the slope after 100 seconds. (16 marks)

3.

3.1 Describe what is resultant and equilibrant force, with the help of a force triangle (6 marks)

3.2 A uniform plank ABC of weight 30N and 2m long is supported at one end A and at point B, 1.4m from A as shown in figure. Find the maximum weight W that can be placed at C, so that the plank does not topple. (14 marks)



4.

4.1 Briefly describe the advantages of using clutch over other power transmitting mechanisms

(6 marks)

4.2 A multi disc clutch has three discs on the driving shaft and two discs on the driven shaft and makes a total of four contact surfaces. The outer diameter of the contact surface is 240mm and inside diameter of that is 120mm. Assuming uniform wear condition, find the maximum intensity of pressure between the discs, when it is running at 1575rpm and transmitting 25kW. Take coefficient of friction between the contact surfaces as 0.3.

(14 marks)

5.

5.1 Write the bending equation and identify the variables with standard units

(6 marks)

5.2 Calculate the maximum stress induced in a cast iron pipe of external diameter 40 mm, internal diameter 20 mm and of a length of 4 meter when the pipe is supported at its end. Consider the pipe carries a point load of 80 N at its center.

(14 marks)

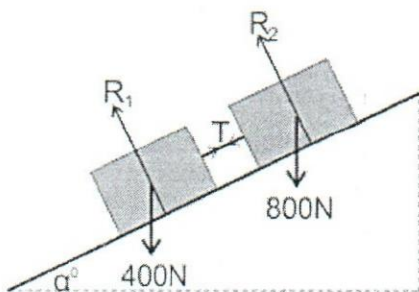
Hint: The Area moment of inertia of a solid circular cross section is given by $\frac{\pi D^4}{64}$

6.

6.1 Write a brief note considering the pros/cons of friction in engineering applications (4marks)

6.2 Two bodies weighing 400N and 800N are placed on an inclined plane as shown in the given figure. A cord parallel to the plane connect the two bodies. The coefficient of sliding friction for the weights 400N and 800N is 0.15 and 0.4 respectively. Determine the inclination of the plane in degrees (α) and tension (T) of the code when the two bodies are at the point of sliding downward.

(16 marks)



7.

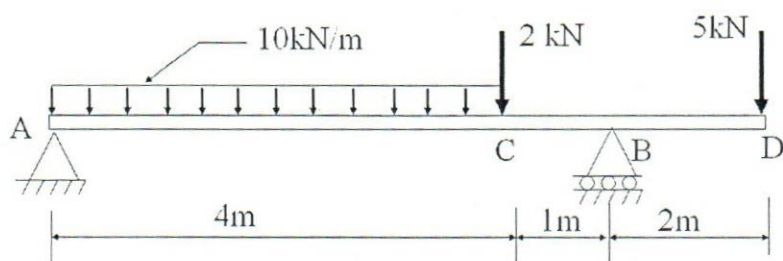
7.1 Below shows an overhanging beam AD loaded with two point load of 2kN and 5kN and one uniformly distributed loads of 10kN/m. For the loading arrangement given;

- Draw shear force diagram
- Draw bending moment diagram.
- Find the contra-flexure point

(7 marks)

(10 marks)

(3 marks)



8.

8.1 Derive Bernoulli's equation for an ideal fluid

(4 marks)

8.2 Fresh water is flowing in a smooth pipe AB having a uniform diameter of 100 cm. It is recorded that 'A' is at an elevation of 15m and having pressure of 55 kPa. The section 'B' of the pipe is at an elevation of 20 m while its pressure is recorded as 30 kPa. The flow rate through a pipe is 1000 liters/s.

- Determine the direction of flow between section 'A' and 'B'.
- What is the total head loss?

(10 marks)

(6 marks)

9.

9.1 Derive the basic expression for hydrostatic pressure

(4 marks)

9.2 A vertical bulkhead divides a 9m wide tank. On one side of the bulkhead there is fresh water to a height of 6.3 m and on the other side there is oil having specific gravity of 0.85. The oil filled to a height of 4.5m from the bottom of the tank. Find;

- The resultant thrust on the bulkhead due to two hydrostatic pressure forces from water and oil
- The position of the center of pressure above the bottom of the tank.

(16 marks)