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PAST PAPERS

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Past Papers

Faculty of maritime Science
Department of Marine Engineering

Engineering Class III (Academic) 2015-2020

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Library 01

DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

MINISTRY OF PORTS AND SHIPPING

DIRECTOR GENERAL'S OFFICE OF MERCHANT SHIPPING

Merchant Shipping Secretariat

Officer in Charge of an Engineering Watch of 750 kW or More (Unlimited)

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:** 10 AUG 2020 **Pass marks: 50%**

Merchant Shipping Secretariat

Part A: NAVAL ARCHITECTURE

1. A vessel having 11800 tonne displacement floating at 6.78 m draft floating in seawater density of 1.025. The half ordinates of water plane at this draft of the vessel are as follows. The Block Coefficient (C_b) of the vessel is 0.85.

Section	AP	1	2	3	4	5	6	7	8	9	10	11	FP
½ Ordinates(m)	2.5	3.6	5.8	7.2	7.8	8.3	8.8	7.4	7.0	6.2	4.7	3.1	0

a. Calculate the area of the water plan of the vessel at this draft. (08 Marks)

b. Find the longitudinal center of floatation (LCF) at this draft. (08 Marks)

2.

a. Regarding Load Line markings of a ship what is known as Fresh Allowance. (02 Marks)

b. When relative densities of Fresh water & sea water are 1.0 & 1.025 respectively, prove that statutory fresh water allowance[FWA] for a ship could be calculated from $FWA = \frac{\Delta}{40\ TPC}$, where Δ (displacement) & TPC are the corresponding values at summer load line draft. (06 Marks)

c. A wall sided vessel of 8000 tonnes displacement in river water berth floats at even keel and draft. The mean draft is noted 50mm below the summer load water line.

The area of the water plane at this draft is 1570 m2.

Find the additional cargo that could be load on board, for vessel to sail at summer load water line when proceeds to sea. (08 Marks)

3. A ship of 10,000 tonne displacement has its center of gravity 6.0 m above the keel (KG). The vessel was modified to install a Ballast Water Treatment plant having mass of 150 tonne with 5.5 m center of gravity above the keel. During modification 50 tonne section of a deck structure was removed from the vessel having 4.5 m center of gravity above keel.

   a. Calculate new vertical center of gravity (kg) of the vessel after the modification. (08 Marks)

Before proceeding for loading port the vessel loaded with 800 tonne of fuel into DB tanks having center of gravity 0.7 m above the keel and 100 tonne of fresh water into F.W. tank having center of gravity 5.2 m above the keel.

   b. Calculate the vertical center of gravity (kg) of the vessel on arrival at the loading port, if 460 tonne of fuel in DB tanks and 50 tonne of fresh water in F.W. tank has been consumed during her passage to loading port. (08 Marks)

4. A ship of 130 m long floating at 4800 tonne displacement with 3.20 m LCG aft of mid-ship.
Following operations took place while the vessel is in a port:
1800 tonne of Cargo loaded @ LCG 5.20 m forward of midship
1250 tonnes of Cargo **discharged** @ 3.43 m forward of midship
20 tonne of fuel consumed @LCG 36.00 m aft of mid-ship
15 tonne of Fresh water consumed @ 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
7.50	5320	47.05	0.60 F	3.50 A

Calculate the final end drafts of the vessel. (16 Marks)

5.

I. Define following terms with respect to marine propellers;
   a. Theoretical Speed (Vt) (02 Marks)
   b. Wake Fraction (w) (02 Marks)
   c. Speed of Advance (Va) (02 Marks)
   d. Real Slip (02 Marks)

II. The diameter & the pitch ratio of a propeller fitted on 130 m long, 10,000 tonne displacement vessel is 6.0 m & 0.8 respectively. The beam of the vessel is 12.0 m and propeller rotate at 120 RPM at 8.0 m design draft in 1.025 tonne/m^3 seawater density.
The wake fraction $w = 0.5C_b - 0.05$ and the real slip is found 36 %.
Calculate;
   a. Speed of advance (04 Marks)
   b. The speed of the ship (02 Marks)
   c. Apparent slip (02 Marks)

6. Resistance exerted by the water on a ship when moves through the water at a speed could be divided into two main components as Frictional Resistance & Residuary Resistance.
   a. List the factors effecting the magnitude of each of above component. (06 Marks)
   b. A 5.0 m mild steel model of a ship has a wetted surface area of 6.0 m^2 and when towed in Sea water at 04 knots, has a total resistance of 48 N.
   Calculate the effective power required for a similar ship having 120 m length, at its corresponding speed, If the "Ship correlation Factor" (SCF) is 1.15. (10 Marks)

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

Part B

7. Regarding structural components of a ship, write short notes on following,
(a) Stern frame. (04 Marks)
(b) Duct Keel. (04 Marks)
(c) Torsion Box. (04 Marks)
(d) Panting beams. (04 Marks)

8.
(a) Using suitable sketches describe a gravity type lifeboat davit. (08 Marks)
(b) Explain the manual braking arrangement. (04 Marks)
(c) Explain how excessive lowering speeds are automatically controlled. (04 Marks)

9. With reference to double plated hollow rudders:
   (a) State the advantages of this type of rudder compared to the single plate rudder. (06 Marks)
   (b) State methods of protecting the rudder from internal corrosion. (04 Marks)
   (c) Describe how the ship and its performance would be affected by a cracked rudder plate which allows the ingress of seawater. (06 Marks)

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DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

MINISTRY OF PORTS AND SHIPPING

DIRECTOR GENERAL'S OFFICE OF MERCHANT SHIPPING

Merchant Shipping Secretariat

Officer in Charge of an Engineering Watch of 750 kW or More (Unlimited)

MARITIME LAW

- **TIME ALLOWED - THREE HOURS**
- **Answer SIX questions only**
- **Date:** 18 AUG 2020 **Pass marks: 50%**

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

Merchant Shipping Secretariat Sri Lanka

1. Referring to Risk Management on board ships, briefly define following terms.
   a. Hazards (03 Marks)
   b. Risk. (03 Marks)
   c. Risk Assessment. (03 Marks)
   d. Control Measures (03 Marks)
   e. List 02 numbers of hazard that could involve with Purifier overhaul and briefly explain the control methods could be used to mitigate the risk from those hazards. (04 Marks)

2. The Law of Sea– III (UNCLOS-III), a convention of the United Nations currently in force.
   a. What are the main objectives of this convention? (02 Marks)
   b. Indicate the various sea areas define by the convention with the aid of a suitable sketch. (05 Marks)
   c. Name three (03) Major international conventions (Except MARPOL) which are currently in force to prevention of sea pollution by maritime activities. (03 Marks)
   d. Define terms "Dumping" & "Operational wastes" as stated in above convention. (06 Marks)

3. International Maritime Organization (IMO) was established in 1948.
   a. What are the primary responsibilities of IMO? (03 Marks)
   b. State the five (05) main committees of IMO. (05 Marks)
   c. What are the five (05) instruments that IMO uses to adopt the various legislations? (05 Marks)
   d. What is mean by "Ratification" of a Convention by a Member state. (03 Marks)

4. 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 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)

5. Survey & Certification is one of the important process of a merchant ships.
   a. Briefly explain why it is required to carry out surveys and issue a certificate for sea going vessels. (02 Marks)
   b. State five (05) parties interested in ship certification. (05 Marks)
   c. Name the main categories of ship certificates. (03 Marks)
   d. State the advantages of Harmonized Survey & Certification system. (02 Marks)
   e. State the main areas covered by the certificate issued to a ship by classification society. (04 Marks)

6. Regarding SOLAS requirements for power operated 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. (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. (06 Marks)
   b. What is mean by "Mandatory Prewash" with reference to Marpol Annex II. (04 Marks)
   c. State the conditions to be met before discharging residues of annex II substances category X, Y or Z OR tank washings or other mixtures into sea. (06 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.
   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)

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MINISTRY OF PORTS AND SHIPPING

DIRECTOR GENERAL'S OFFICE OF MERCHANT SHIPPING

Merchant Shipping Secretariat

Officer in Charge of an Engineering Watch of 750 kW or More (Unlimited)

APPLIED MECHANICS

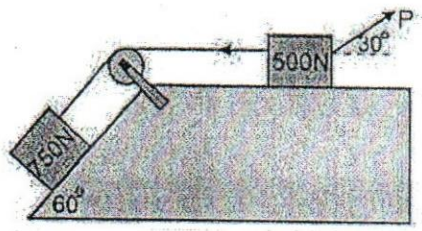
- **TIME ALLOWED - THREE HOURS**
- **Answer ANY Six questions only**
- **Date: 2020.....** 11 AUG 2020 **Pass marks: 50%**

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

1.

1.1 Distinguish between angle of friction and angle of repose, and derive the mathematical relationship between the two. (6 Marks)

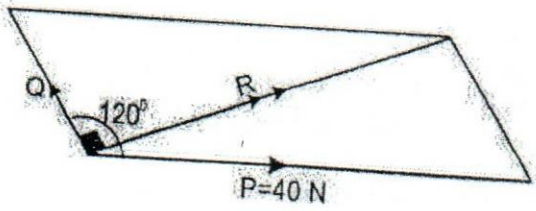
1.2 Two blocks of weight 500N and 750N are connected by a weightless string as shown in the figure below. If a "P" force is applied to the system with a 30^0 inclination to the horizontal, what is the value of P in the system cause the motion to impend (stop)? Assume the pulley is smooth and coefficient of friction between the other contact surfaces is 0.2. (14 Marks)



2.

2.1 Using a suitable figure show that the resultant of two co-plainer, concurrent forces 'P' & 'Q' having 'θ' angle between them, can be written in the form of, $R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$. Hence derive an expression for the resultant force if the angle between the forces is 90^0. (8 Marks)

2.2 Two forces act at an angle of 120^0 from each other as shown in below figure. The bigger force is 40N and resultant is perpendicular to the smaller one. Find the value of the smaller force. (12 Marks)



3.

3.1 A small steel ball is shot vertically upward from a balcony of a building situated 25m above the ground with an initial velocity of 18m/sec

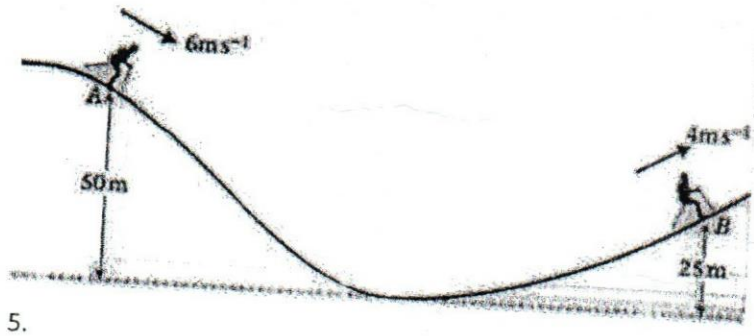
a. In what time, it will reach the maximum height? (4 marks)
b. How high above the balcony will the ball rise? (4 marks)
c. Compute the velocity with which it will strike the ground and the total time it is in motion (4 marks)

3.2 Another steel ball was dropped vertically downward from another balcony of the building. It was found that on its way down it falls past a window of 2.45m height within half a second. Find the height to the balcony from the window. (8 marks)

4.

4.1 A skier passes point A on a ski run moving downhill at 6 ms^{-1}. After descending 50 m vertically the run begins to ascend. When the skier has ascended 25 m to point B his speed is 4 ms^{-1}. The skier and his skis have a combined mass of 55 kg. The total distance he travels from A to B is 1400 m. The resistance from the ground surface to the motion are constant throughout the motion and have a magnitude of 12 N. Calculate;

a. Kinetic energy loss (6 marks)
b. Potential energy loss (6 marks)
c. Work done by the skier (8 marks)

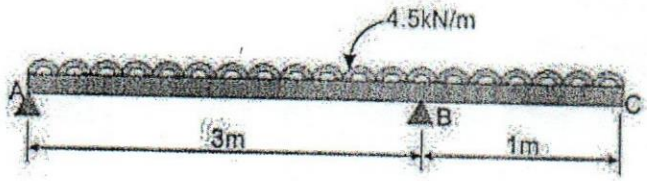


5.

5.1 Describe what you understand by the term "point of contra-flexure". (5 Marks)

5.2 Draw shear force diagram and bending moment diagram for the 4m long overhanging beam shown below. Clearly indicate the sign convention used and values of all important points on both diagrams.

(15 Marks)



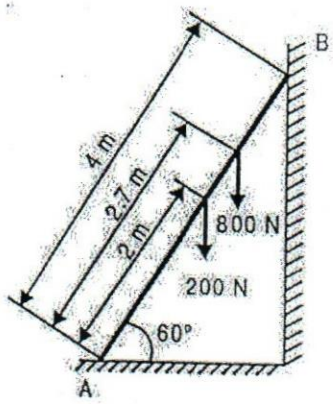
6.

6.1 A pipeline carrying oil of specific gravity 0.87, changers in diameter from 200 mm diameter at a position A to 500mm diameter at a position B which is 4 meters at a higher level. If the pressure at A and B are 9.81 N/cm2 and 5.886 N/cm2 respectively and the discharge is 200 liters/s determine the loss of head and direction of flow. (20 Marks)

7.

7.1 *Briefly* describe two practical situations from the industry that the ***friction*** needs to be maximize and minimize. (5 Marks)

7.2 A ladder of length 4 m, weighing 200 N is placed against a vertical wall as shown in below figure. The coefficient of friction between the wall and the ladder is 0.2 and that between floor and the ladder is 0.3. The ladder, in addition to its own weight, has to support a man weighing 600 N at a distance of 3 m from A. Calculate the minimum horizontal force to be applied at A to prevent slipping. (15 Marks)



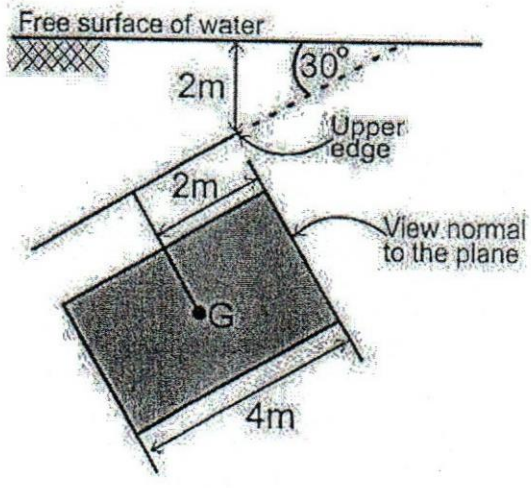
8.

8.1 A plate clutch having a single driving plate with contact surfaces on each side is required to transmit 110kW at 1250 rpm. The outer diameter of the contact surfaces is to be 300mm. the coefficient of friction is 0.4.

a. Assuming a uniform pressure of 0.17 N/mm2; determine the inner diameter of the friction surfaces. (10 Marks)
b. Assuming the same dimensions and the same total axial thrust, determine the maximum torque that can be transmitted and the maximum intensity of pressure when uniform wear condition have been reached. (10 Marks)

9.

9.1 A rectangular plane surface 3m wide and 4m long lies in water in such a way that its plane makes an angle of 30^0 with the free surface of water. Determine the total pressure force and position of center of pressure, when the upper edge of the plane is 2m vertically below the free surface. (20 Marks)



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DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

MINISTRY OF PORTS AND SHIPPING

DIRECTOR GENERAL'S OFFICE OF MERCHANT SHIPPING

Merchant Shipping Secretariat

Officer in Charge of an Engineering Watch of 750 kW or More (Unlimited)

ELECTROTECHNOLOGY

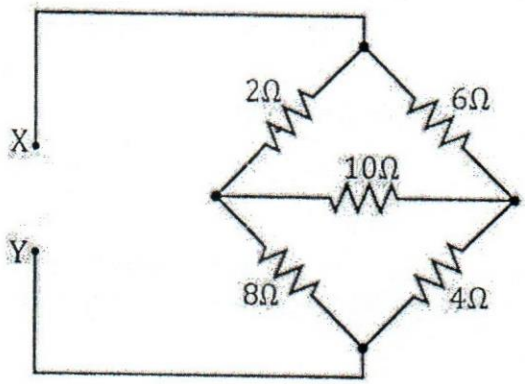
- TIME ALLOWED - THREE HOURS
- Answer ANY FOUR questions from part A and ANY TWO questions from part B
- Date: 12 AUG 2020 Pass marks: 50%

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

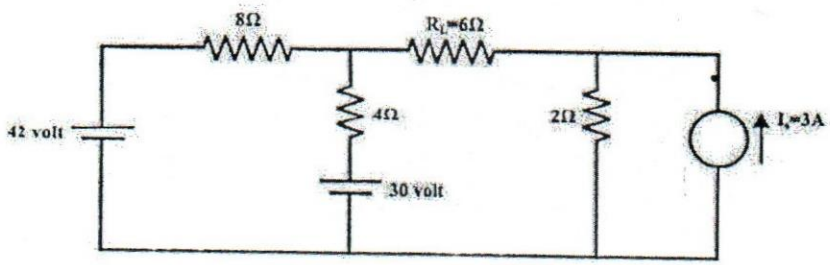
Part A

1. a) State Kirchhoff's laws and Ohm's law in electricity. (6 marks)

b) Find the equivalent resistance between X and Y using Delta-Star transformation. (5 marks)



c) If internal resistance of current source is infinity and all voltage source are ideal, find the current I_L through 6 Ω resistor using Thevenin's theorem or otherwise. (9 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 series across a 40V, 20kHz supply:

- a resistance of Ω
- a coil of inductance 130μH and 5 Ω resistance
- a 10Ω resistor in series with a 0.25μF capacitor.

Calculate

i. the circuit current (4 marks)

ii. the circuit phase angle and (4 marks)

iii. the voltage drops across each impedance. (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 50 Ω and 0.1 Ω respectively. If iron and friction losses amount to 1600 W, find

a) copper losses (6 marks)

b) efficiency (8 marks)

c) 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 μWb passing through a 150-turn coil is reversed in 40 ms. Find the average e.m.f. induced. (4 marks)

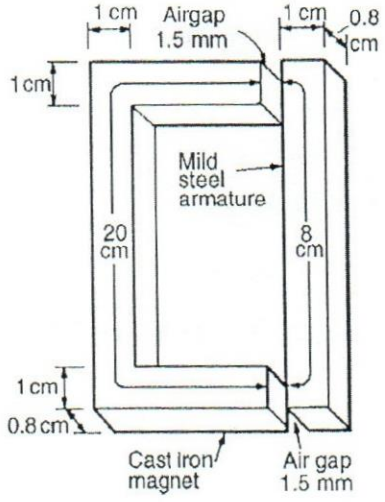
c) Two coils A and B having turns 100 and 1000 respectively are wound side by side on a closed iron circuit of cross-sectional area 8 cm2 and mean length 80 cm. The relative permeability of iron is 900. Calculate

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 0.02 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 single phase a.c. generator supplies the following loads:

- Lighting load of 20 kW at unity power factor.
- Induction motor load of 100 kW at p.f. 0·707 lagging.
- Synchronous motor load of 50 kW at p.f. 0·9 leading.

Calculate

a) the total kW and kVA delivered by the generator. (10 marks)
b) the power factor at which it works. (10 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 Alternators 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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MINISTRY OF PORTS AND SHIPPING

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Officer in Charge of an Engineering Watch of 750 kW or More (Unlimited)

Class III Marine Engineering Drawing and Design (ED 287) Time 04 Hrs

Figure, on the insert, shows details of the component parts of a **Parallel Slide Stop Valve** which can be used on high pressure steam when placed in a pipe line.

Using a suitable scale, draw the following views of fully assembled **Parallel Slide Stop Valve** in **first angle projection**:

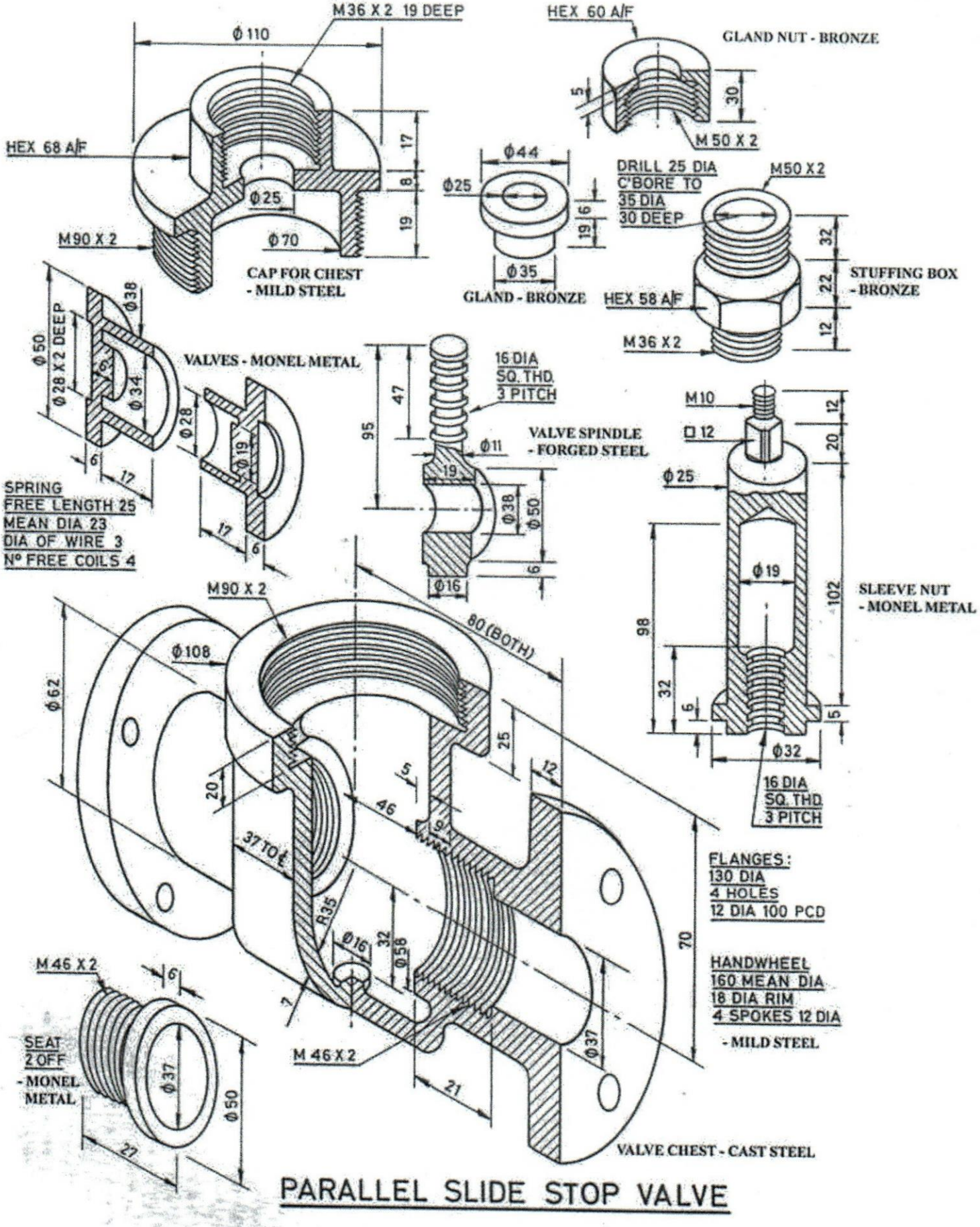
(a) Sectional elevation, showing the Valve in the **closed position**. The plane of the section should be through the branches.

(b) End elevation projected to the right of **(a)**

Suitable dimensions should be estimated where not provided. Complete the drawing by including the title, projection symbol, dimensions and a list of materials of parts.

Marking System

(i). Assembling accuracy of view (a)	(45 marks)
(ii). Assembling accuracy of view (b)	(30 marks)
(iii). Optimization of space	(05 marks)
(iv). Dimensioning	(05 marks)
(v). List of materials of parts	(05 marks)
(vi). Title block, projection symbol, lettering	(05 marks)
(vii). Final appearance, neatness	(05 marks)



PARALLEL SLIDE STOP VALVE

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

MARINE ENGINEERING DRAWING AND DESIGN

- **TIME ALLOWED - FOUR HOURS**
- ***Answer All questions***

Date: 2020.01.22 ***Pass marks: 50%***

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

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The figure shows details of a **control valve**. Draw the following views of the assembled control valve in **first angle projection**. Select a suitable scale.

(a) Longitudinal section through assembled valve with fulcrum- pin (item 7) vertically above right-hand branch. Valve should be in closed position.

(b) End elevation projected to the right of (a)

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

Marking System

(1) Assembling accuracy of view (a)	(45 marks)
(2) Assembling accuracy of view (b)	(35 marks)
(3)Optimization of space	(05 marks)
(4) Dimensioning (at least 12 dimensions correctly)	(06 marks)
(5) Title block, projection symbol, lettering	(04 marks)
(6) Final appearance	(05 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: 2020.01.17** **Pass marks: 50%**

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

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1.

a. Solve $x^2 - 4x + 3 = 0$ (5 marks)

b. The quadratic equation $x^2 - px + 10 = 0$ has real roots α and β.

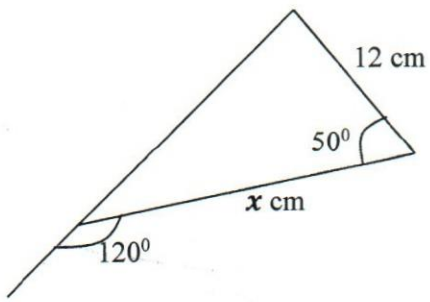
i. Find $\alpha + \beta$ and $\alpha\beta$. (5 marks)

ii. Given that $\alpha^2 + \beta^2 = 5$, find the possible values of p. (5 marks)

c. Find the equation of the straight line L_1 with gradient 2 and passing through the point (-2, 3). (5 marks)

2.

a. State the Sine rule for a triangle. Use the sine rule to find the value **x** of given triangle. (6 marks)



b. If $3\,\mathrm{Sin}\,\theta = 2\,\mathrm{Cos}\,\theta$, find the value of

i. $\mathrm{Cosec}\,\theta$ (4 marks)

ii. $\mathrm{Sec}\,\theta$ (4 marks)

c. Prove the following identity, $\mathrm{Tan}\,x + \dfrac{1}{\mathrm{Tan}\,x} = \dfrac{1}{\mathrm{Sin}\,x.\mathrm{Cos}\,x}$ (6 marks)

3.

a. Let $z_1 = 3+3i$ and $z_2 = \sqrt{3}-i$

i. Convert complex numbers z_1 and z_2 to polar form (4 marks)

ii. Compute the followings

(a) $z_1 z_2$ (b) z_1/z_2 (c) z_2/z_1 (6 marks)

iii. Evaluate the followings

(a) $|z_1/z_2|$ (b) $\arg(\frac{z_1}{z_2})$ (4 marks)

Hint: $r\angle\theta \equiv r(Cos\theta + i\,Sin\theta)$

b. Find the square root of $2+i$ (6 marks)

4.

a. Given the matrix, $A = \begin{pmatrix} 1 & 3 & 3 \\ 1 & 4 & 3 \\ 1 & 3 & 4 \end{pmatrix}$ find the adjoint of A. (8 marks)

b. Hence find the inverse of A (2 marks)

c. 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)

5.

a. Solve the equation $\log_3 x - 4\log_x 3 - 3 = 0$ (5 marks)

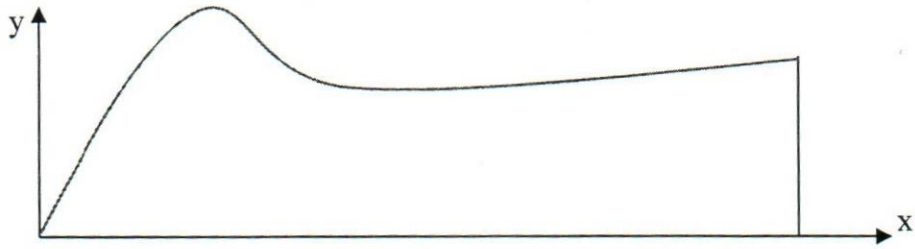
b. Express as the sum of its partial fractions

i. $\dfrac{3x+1}{(x-1)^2(x+2)}$ (5 marks)

ii. $\dfrac{4x^3+10x+4}{x(2x+1)}$ (5 marks)

c. Solve the inequality, $x^2 - 5x + 6 > 0$ and draw the graph. (5 marks)

6. Figure represents a lamina made by coordinates given in the table below. Use the table and figure for the followings



x(m)	*0*	*0.5*	*1.0*	*1.5*	*2.0*	*2.5*	*3.0*	*3.5*	*4.0*	*4.5*	*5.0*	*5.5*	*6.0*	*6.5*	*7.0*	*7.5*	*8.0*
y(m)	*0*	*0.25*	*0.75*	*0.85*	*0.75*	*0.65*	*0.6*	*0.58*	*0.59*	*0.60*	*0.61*	*0.62*	*0.63*	*0.64*	*0.65*	*0.66*	*0.67*

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)

7.

a. Differentiate from first principle, $y = \dfrac{1}{2x-1}$ (3 marks)

b. Find the gradient of the curve $y = x^3 - 4x^2 + 6x - 3$ at the point of (0, -3). (3 marks)

c. Differentiate by using product rule $y = (2x+3)^3 (3x+2)^2$ (4 marks)

d. Find $\dfrac{dy}{dx}$ and $\dfrac{d^2y}{dx^2}$ of $y = \dfrac{x^3+1}{x}$. (4 marks)

e. If $y = x^3$ prove that $2x^2 \dfrac{dy}{dx} = y\dfrac{d^2y}{dx^2}$ (6 marks)

8.

a. Evaluate the followings

(i) $\int \left(2x + \dfrac{1}{x}\right)^2 dx$ (ii) $\int \text{Sin}^2 x\, dx$ (iii) $\int \dfrac{x+1}{x^2-2x-15} dx$ (9 marks)

b. Find the area of the region R bounded by $y = x^3$, $x = 0$, $x = 2$ (5 marks)

c. If R is rotated around x axis by a complete angle, find the volume of the solid generated. (6 marks)

9.

a. If $v=\left(x^2+y^2+z^2\right)^{m/2}$ then find the value of m (m ≠ 0) which will make

$$\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}+\frac{\partial^2 v}{\partial z^2}=0$$

(10 marks)

b. If $f(x,y)=x^3y-xy^3$ find the all first order and second order partial derivatives.

(10 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

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: 2020.01.13** **Pass marks: 50%**

Part A: NAVAL ARCHITECTURE

1.

a) State Simpson's second rule and indicate the shape of which the curve is approximated to. (02 marks)

b) Half breadth values which are measured at equal intervals from end to end of a ship's water plane having 94.0 m length are as below.

0.6m, 2.9m, 7.6m, 10.6m, 10.9m, 10.1m, 7.5m, 3.2m, 1.2m, 0

Find the area of water plane and COF of the water plane area at that draft. (14 marks)

2.

a) Define "Meta-centric height (GM)" (02 marks)

b) A ship arrives in port with displacement 6000 tonnes and KG 6m. She then discharges and loads the following quantities:

Discharge

1250 tonnes of cargo	KG 4.5 metres
6 675 tonnes of cargo	KG 3.5 metres
420 tonnes of cargo	KG 9.0 metres

Loads

980 tonnes of cargo	KG 4.25 metres
550 tonnes of cargo	KG 6.00 metres
700 tonnes of bunkers	KG 1.0 metre
70 tonnes of FW	KG 12.0 metres

During the stay in port 30 tonnes of oil (KG 1m) are consumed.
If the final KM is 6.8m, find the GM on departure. (14 marks)

3.

A vessel displacing 16398 tonnes; KM 8.245m, KG 7.15m, Free Surface Correction (FSC) 0.8m, discharged 280 tonnes, KG 6.2m C of G 1.4 off the centerline to STBD,
Loaded 280 tones KG 6.2m C of G 3.5m to STBD off the centerline,
A 70 tonnes parcel of cargo shifted horizontally from 3.6m port to 1.2m port of the centerline.
Calculate the resultant List. (16 Marks)

Note: 280 tonne discharged and 280 loaded with same KG 70 tonnes shifted only horizontally, therefore ship's KG will remain unchanged. FSC will also remain unchanged.

4. A ship 120 m long has displacement of 5450 tonnes and LCG 2.40 m aft of mid-ship.
Following operations were carried out during the port stay of the ship:
Cargo 800 tonne discharged @ Lcg 4.20 m forward of mid-ship
Cargo 3300 tonne loaded @ Lcg 10.50 m forward of mid-ship
Fuel 520 tonne loaded @ Lcg 35.50 m aft of mid-ship
Water 15 tonne consumed @ Lcg 36.25 m aft of mid-ship
Stores 5 tonne loaded @ Lcg 38.0 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
8.0	8460	48.80	1.25 F	1.20 A

Calculate the final end drafts of the vessel after the port operation. (16 Marks)

5.

a. With reference to resistance exerted on ship's hull against her movement through seawater explain following terms.
   I. Frictional Resistance. (02 Marks)
   II. Residuary Resistance. (02 Marks)
   III. List the factors effecting the magnitude of Frictional Resistance. (02 Marks)

b. A 05 m long mild steel model of a ship has a wetted surface area of 6 m^2 and required 46 N force to tow it in fresh water at 04 knots.
Calculate the effective power required for 120m long similar ship with mild steel hull, at its corresponding speed allowing 10% for the "Ship correlation Factor" (SCF).
$f = 0.417 + \frac{0.773}{L+2.862}$ for mild steel hull in sea water density of 1.025 t/m^3 and the index of speed is 1.825 for the Froude's formula, where wetted surface area is in m^2 & speed is in Knots. (10 Marks)

6. a) Define following terms with respect to marine propellers;

   i. Pitch (02 Marks)
   ii. Wake Fraction (02 Marks)
   iii. Apparent Slip (02 Marks)
   iv. Real Slip (02 Marks)

   b) The Pitch Ratio of 5.60m diameter propeller is 0.8. Prismatic Coefficient (C_p) of the ship is 0.80 and Midship Section Area Coefficient (C_m) is 0.95. When propeller rotates at 120 RPM, the wake fraction $w = 0.5C_b - 0.05$ & the real slip is 35 %.

   Calculate;

   i. Speed of advance (04 Marks)
   ii. The speed of the ship (02 Marks)
   iii. Apparent slip (02 Marks)

PART B: SHIP CONSTRUCTION

7. With simple sketch explain the function, construction and location of the following structural members of a ship. (16 marks)
   a) Gunwale
   b) Sheer strake
   c) Intercostal Side girder
   d) Longitudinal

8. a) Sketch and describe the different types of floors used in the construction of a double bottom identifying various structural components / various constructional features in cooperated. (08 marks)

   b) Define and explain via a free hand sketch (08 marks)

      i. Moulded Depth
      ii. Extreme breath (Beam)
      iii. Extreme Draft
      iv. Extreme Depth

9. a) Describe The function of the stern frame (02 marks)
   b) Explain the construction of transom stern with an aid of freehand sketch. (04 marks)
   c) Write short notes on following (04 marks)

      i. Pounding
      ii. Panting
      iii. Bilge strum box
      iv. Wash Bulk head

   d)
      i. Explain the importance of ballast water system management (03 marks)
      ii. With a aid of sketch explain how water ingress is prevented in an air/vent pipe (03 marks)

00025

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 SIX questions only**

Date: **Pass mark: 50%**

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

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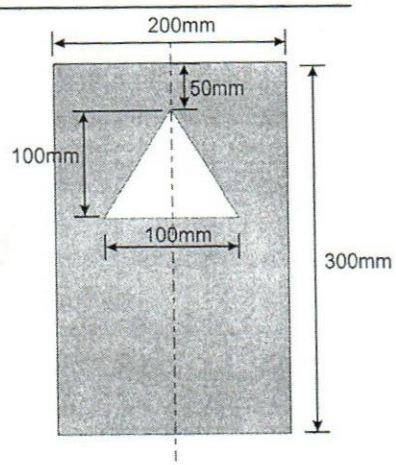
Density of water – 1000 kgm^{-3} Gravitational acceleration – 9.81 ms^{-2}
Density of sea water – 1100 kgm^{-3}

1.

1.1 A triangular hole is made in a rectangular section as shown in the diagram. Determine the moment of inertia of a section about horizontal and vertical axes passing through its center of gravity.

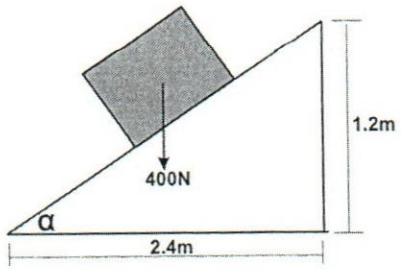
(20 Marks)



2

2.1 "friction is a self-adjusting force" explain the statement briefly. **(6 Marks)**

2.2 An inclined plane as shown in the figure is used to unload slowly a body weighing 400N from a truck 1.2m high into the ground. The coefficient of friction between the underside of the body and the plank is 0.3. State whether it is necessary to push the body down the plane or hold it back from sliding down. What minimum force is required parallel to the plane for this purpose?



(14 Marks)

3

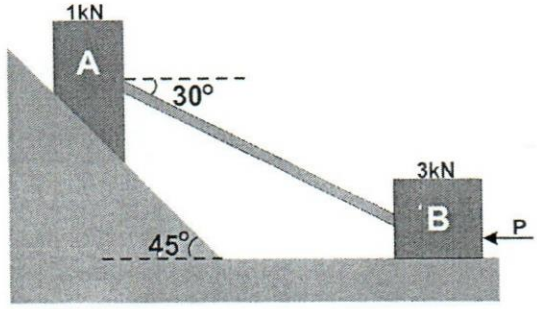
3.1 Define Simple Harmonic Motion and derive an expression for frequency of vibration of a spring. **(8 Marks)**

3.2 A helical spring, negligible mass and which is found to extend 0.25 mm under a mass of 1.5kg, is made to support a mass of 60 kg. The spring and the mass system is displaced vertically through 12.5 mm and released. Determine the frequency of natural vibration of the system. Find also the velocity of mass, when it is 5 mm below its rest position. **(12 Marks)**

4

4.1 Define coefficient of friction and angle of repose? **(4 Marks)**

4.2 A block "A" weighing 1kN rests on a rough inclined plane whose inclination to the horizontal is 45^0. This block is connected to another block "B" weighing 3kN rests on a rough horizontal plane by a weightless rigid bar inclined at an angle of 30^0 to the horizontal as shown in the below figure. Find horizontal force "p" required to be applied to the block "B" just to move the block "A" upward direction. Assume angle of limiting friction as 15^0 at all surface where there is sliding.



(16 Marks)

5.

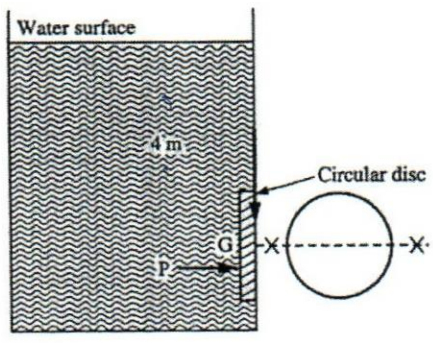
5.1Derive four linear motion equations and deduce them to represent the maximum height and total time taken for the vertical motion of an object under gravity. **(6 Marks)**

5.2 A cage descends in a mine shaft with an acceleration of 0.5 m/s^2. After the cage has travelled 25m, a stone is dropped from the top of the shaft. Determine;

a. the time taken by the stone to hit the cage **(7 Marks)**
b. distance travelled by the cage before impact **(7 Marks)**

6

6.1 A vertical rectangular tank is provided with a circular hole of diameter 3m on one side of its vertical sides. It is closed by a disc of 3m diameter which can rotate about the horizontal diameter as given in figure. Calculate,



a. The force on the disc
(8 Marks)
b. The torque required to maintain the disc in equilibrium when the head of water above the center of the disc is 4m.
(12 Marks)

7

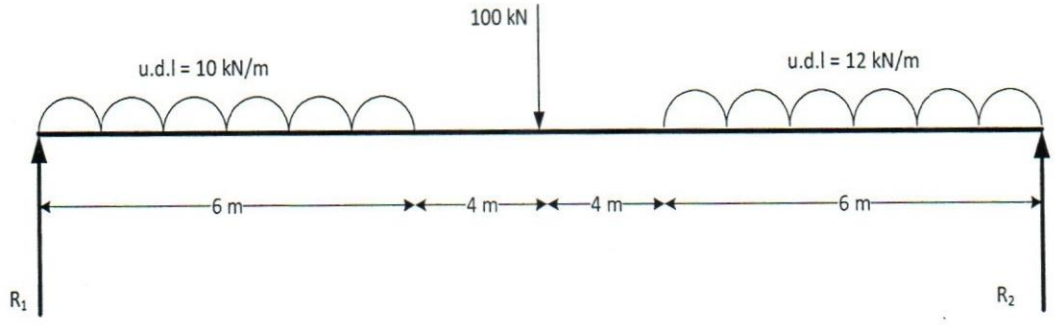
7.1State three Newton's Laws of motion and obtain the relationship between the applied external force (F) and resulting acceleration **(6 Marks)**

7.2 A truck weighing 6 kN moves freely (engine is not running) at 36km/h down a slope of 1 in 40. The road resistance at this speed is just being sufficient to prevent any acceleration of the truck. Find the road resistance per kN weight of truck. What power will the engine have to exert to run up the same slope at double the speed when the road resistance remains the same? **(14 Marks)**

8

8.1 Below figure shows the loading applied on the simply supported beam. Two UDLs are acting on the beam as shown;

a. Determine the reactions, R1 and R2. **(3 Marks)**
b. Draw the Bending moment and Shear force diagram **(15 Marks)**
c. Determine maximum bending moment and point where it occur. **(2 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. 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 line. Further the flow rate through the pipe is noted to be 60 m^3/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

MARINE ENGINEERING DRAWING

- **TIME ALLOWED - FOUR HOURS**

Date: **Pass mark: 50%**

Instructions to Candidates:

- **The scale used must ensure uniform distribution and coverage of the drawing sheet**
- **Credit will be given to correct spacing of views neatness and accuracy**
- **All construction lines must be clearly shown and do not erase**
- **Write your index number clearly at the right-hand bottom corner of the drawing paper**

The figure shows details of a **Crane Hook**.

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

(a) Sectional Elevation through the horizontal axis of the Swivel block showing all parts assembled.

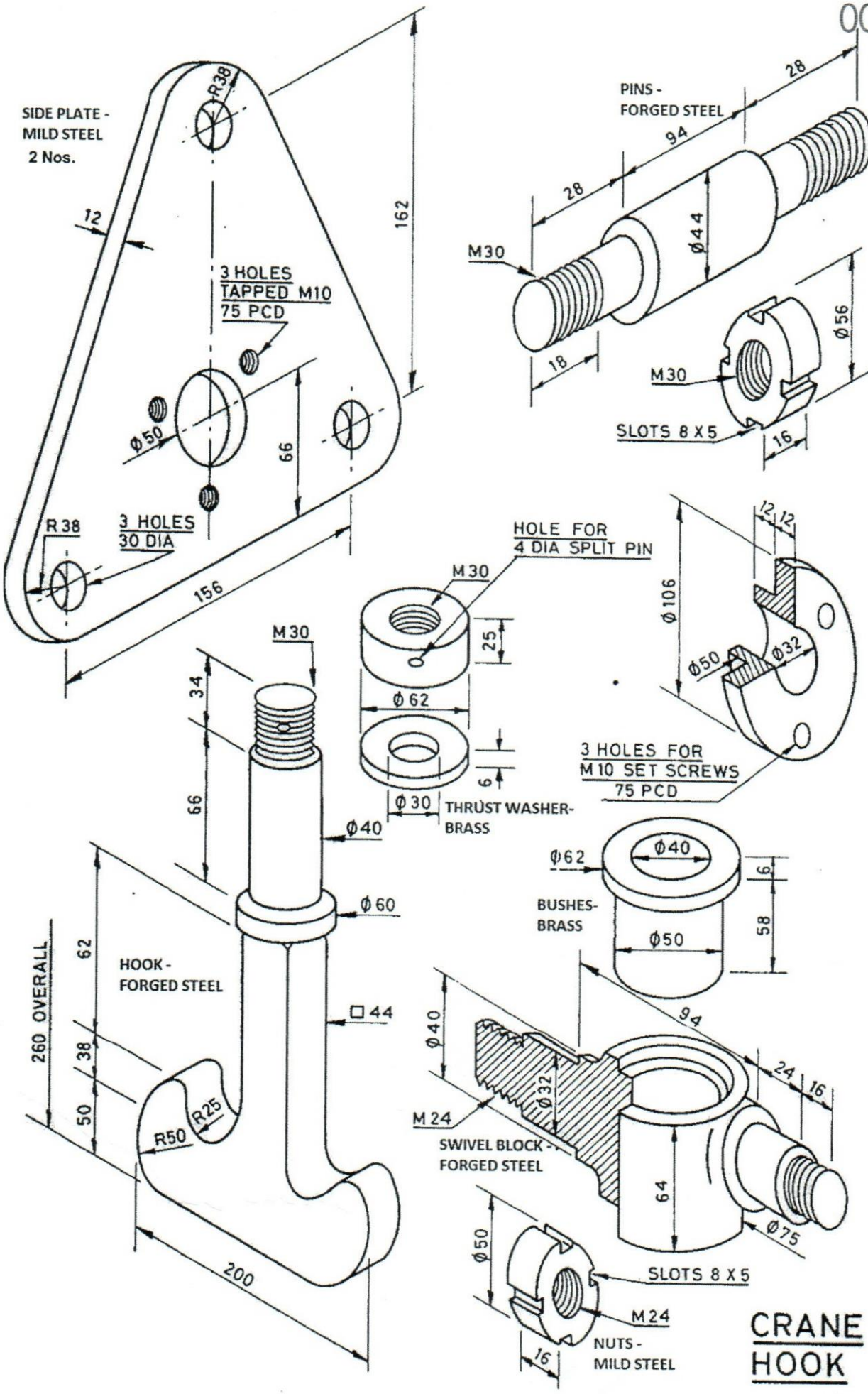
(b) End Elevation projected to the right of (a)

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)


SIDE PLATE -
MILD STEEL
2 Nos.
R38
12
162
3 HOLES
TAPPED M10
75 PCD
Ø50
66
R38
3 HOLES
30 DIA
156
PINS -
FORGED STEEL
28
94
28
M30
Ø44
18
M30
Ø56
SLOTS 8 X 5
16
HOLE FOR
4 DIA SPLIT PIN
M30
25
Ø62
6
Ø30
THRUST WASHER-
BRASS
12
12
Ø106
Ø50
Ø32
3 HOLES FOR
M10 SET SCREWS
75 PCD
M30
34
66
Ø40
Ø60
□44
260 OVERALL
62
38
50
HOOK -
FORGED STEEL
R50
R25
200
Ø62
Ø40
6
BUSHES-
BRASS
58
Ø50
94
Ø40
Ø32
24
16
M24
SWIVEL BLOCK -
FORGED STEEL
64
Ø75
Ø50
SLOTS 8 X 5
M24
NUTS -
MILD STEEL
16

CRANE HOOK

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:** **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, briefly define following terms;
   a. Hazards (03 Marks)
   b. Risk. (03 Marks)
   c. Risk Assessment. (03 Marks)
   d. Control Measures (03 Marks)
   e. List 02 numbers of hazard that could involve with Purifier overhaul and briefly explain the control methods could be used to mitigate the risk from those hazards (04 Marks)
2. International Maritime Organization (IMO) was established in 1948.
   a. What are the primary responsibilities of IMO. (03 Marks)
   b. State the five (05) main committees of IMO. (05 Marks)
   c. What are the five (05) instruments that IMO uses to adopt the various legislations (05 Marks)
   d. What is mean by "Ratification" of a Convention by a Member state. (03 Marks)
3. With reference to the Convention of "Law of the Sea", Explain the followings
   a. Innocent passage (03 Marks)
   b. Exclusive Economic Zone (03 Marks)
   c. Transit Passage (03 Marks)
   d. Briefly explain the Rights and Responsibilities of authorities at each sea areas. (07 Marks)
4. With reference to SOLAS convention Chapter II-2;
   a. State the fire safety objectives of Chapter II-2. (06 Marks)
   b. Define two main types of bulkheads used in ship construction to fulfill above safety objectives. (06 Marks)
   c. State what is meant by a "Non-Combustible" material. (04 Marks)

5.

a. What are the important amendments made to the STCW convention at Manila in 2010 (04 marks)

b. What are the objectives of the ISM Code (04 Marks)

c. Define followings with reference to ISM,

i. Observation (04 Marks)

ii. Non conformity (04 Marks)

d. Outlines the main content of the SOLAS training manuals on board. (04 Marks)

6. 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? (09 Marks)

c. What is mean by "Mandatory Certificate". (02 Marks)

d. State 04 advantages of Harmonized Ship Survey & Certification system. (04 Marks)

7. As per Marpol convention

a. State the provision in Marpol Annex I with regard to discharge of oily bilge mixtures from ships while in special area and outside of special area. (04 Marks)

b. List down the entries to be made in oil record book part I and part II. (04 Marks)

c. What are the requirements to be fulfilled before discharging sewage in to the sea from sea going vessel? (04 Marks)

d. State the principle amendments made to Marpol Annex-V in March 2018 (04Marks)

8. Emission of various gases from merchant ships are subjected to control by Marpol Annex VI.

a. State five (05) gases comes under control of Marpol Annex VI. (05 Marks)

b. Explain the effect of "Green House Gasses" on global warming. (02 Marks)

c. Name four (04) Green House gases. (04 Marks)

d. What are the certificates & documents required to carry on board ships to comply with annex VI requirements. (05 Marks)

9.

a. State the main objectives of assigning Free Board for a ship. (04 Marks)

b. What is meant by "Free Board" & "Reserve Buoyancy" of a ship? (06 Marks)

c. List 06 different types of items comes under Record of Conditions of Assignment for assigning Load Line for a ship. (06 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

THERMODYNAMICS

- **TIME ALLOWED - THREE HOURS**
- **Answer SIX questions only**
- **Date:** **Pass marks: 50%**

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

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

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.

a. Draw the ***P-H diagram*** for steam including ***saturated vapour line***, ***wet vapour region***, ***saturated liquid line***, ***critical point*** and ***gases region***. (5 marks)

b. A quantity of steam at a pressure of ***0.5 bar,0.9*** dry occupies ***0.25 m^3***. The steam is expanded under constant pressure to ***0.3336 m^3***. Determine

i. The mass of steam present (3 marks)
ii. The work transfer (3 marks)
iii. The quality of the steam after the expansion (4 marks)
iv. Heat exchange between steam and surrounding, stating the direction (5 marks)

2. A low grade fuel with ***68 %*** of ***Carbon (12)***, ***12 %*** of ***Hydrogen (1)***, ***3 %*** of ***Sulphur(32)***, ***6 %*** of ***Oxygen(16)*** and the remaining incombustible material. Estimate

i. The high calorific value of the fuel (4 marks)
ii. The lower calorific value of the fuel (4 marks)
iii. The stoichiometric air/fuel ratio (4 marks)
iv. The composition of the exhaust gas on percentage mass basis. (8 marks)

Take the calorific values of ***C, H*** and ***S 33.7, 144*** and ***9.3 MJ/kg*** respectively.

3. A spark ignition engine works an air standard ***Otto cycle*** that has a heat addition of ***1800 kJ/kg*** and a compression ratio of ***7***. The pressure and temperature at the beginning of the compression are ***1.03 bar*** and ***298 K***. Determine

   a. The maximum pressure and temperature of the cycle (5 marks)

   b. The specific work done (5 marks)

   c. Thermal efficiency of the cycle (5 marks)

   d. The mean effective pressure (5 marks)

4.

   a. State the ***Fourier law in heat transfer***. (2 marks)

   b. Describe the ***overall heat transfer coefficient*** (2 marks)

   c. The walls of a cold chamber consists of an outer layer of wood of thickness ***30 mm*** and thermal conductivity ***0.18 W/m K***, and cork layer of thickness ***70 mm*** and thermal conductivity ***0.05 W/mK***and inner layer of steel of thickness ***5 mm*** and thermal conductivity ***17.3 W/mK***. If the rate of heat transfer from and to each exposed surface is ***10 W/m^2K*** and the heat flow thorough the wall is ***24 W/m^2***, determine

      i. The ***overall heat transfer coefficient*** including outer and inner fluid layers (4 marks)

      ii. The ***temperature difference*** across the thickness of the wood, cork and steel (4 marks)

      iii. The ***total temperature difference*** between the outside atmosphere and inside of room (4 marks)

      iv. The ***temperature of the room*** when the external ambient temperature is ***20 ^0C*** (4 marks)

5. In an ideal ***Dualcombustion cycle*** the volume compression ratio is ***11:1*** and the initial conditions of air are ***1.013 bar*** and ***300 K***. The maximum pressure of the cycle is ***41.4bar*** and the maximum temperature is ***1600 K***. Determine

   i. Temperature and pressure at the end of compression (4 marks)

   ii. The constant volume heat transfer (4 marks)

   iii. The percentage of the fuel admission under constant pressure from the stroke (4 marks)

   iv. The heat rejection under constant volume (4 marks)

   v. The cycle efficiency (4 marks)

6. A single cylinder, four stroke gas engine ***23 cm*** in diameter and ***40 cm*** in stroke runs at ***180 rpm***. The following readings are taken. The number of explosions is ***85 per min***, load on the brake wheel is ***810 N***, spring balance reading is ***100 N***, brake wheel diameter is ***152 cm***, the indicated diagram length and area are ***27 mm*** and ***450 mm^2***, indicator calibration is ***31.8 kPa/mm***, gas used is ***7.2 m^3/h***, calorific value of the fuel is ***21.5 MJ/kg***. Estimate

   a. The mean effective pressure (2 marks)

   b. Indicated power (4 marks)

   c. Brake power (4 marks)

   d. Indicated and brake specific fuel consumption (4 marks)

   e. The mechanical, indicated and brake thermal efficiency (6 marks)

7. A vapour compression refrigeration system (***R -22***) of ***10 tonnes*** capacity (*refrigerating effect*) operates with a condensing temperature of ***35 ^0C*** and evaporating temperature of ***-10 ^0C***. The refrigerant leaves the evaporator as dry vapour and leaves the condenser as saturated liquid.

   a. Draw the T-S and P-H diagram for the cycle (4 marks)

   b. Estimate

      i. The condition of the refrigerant at the evaporator inlet (4 marks)

      ii. The mass flow rate of the refrigerant (4 marks)

      iii. Power required by the compressor (4 marks)

      iv. The Coefficient of Performance (4 marks)

   1 tonne = 3.8 kW

P_s, (bar)	V_g, (m^3/kg)	t_s (^0C)	*Enthalpy, kJ/kg*		*Entropy, kJ/kg K*		*Degree of superheat 30 ^0C*	
			h_f	h_g	s_f	s_g	h	s
3.543	0.06534	-10	33.01	246.14	0.1324	0.9422	266.84	1.0188
9.099	0.02600	20	68.67	187.84	0.2590	0.8997	280.50	0.9786
13.548	0.01727	35	87.70	260.22	0.3210	0.8809	285.78	0.9708

8. A single stage single acting air compressor takes in air at ***1.013 bar*** and ***27 ^0C*** and compresses it to ***12 bar*** and delivers at a rate of ***0.08 m^3/s***. If the compression and expansion follow the law ***$pV^{1.25}$ = constant***. The clearance volume is ***5%*** of the swept volume and the swept volume is ***0.045 m^3***. Estimate

   a. The temperature at the end of compression and the internal energy change of the air (5 marks)

   b. The power required to drive the compressor (5 marks)

   c. Speed of the compressor (5 marks)

   d. Volumetric efficiency (5 marks)

9. Steam enters the turbine of a steam power plant at ***70 bar*** and ~~***50 ^{0}C***~~ 500 °C and exhausts to the condenser at ***0.1 bar***. The turbine produces a power of ***200 MW*** with an isentropic efficiency of ***87%***.

   a. Draw the T-S diagram (4 marks)

   b. Determine the followings

      i. The condition of the steam after the expansion in the turbine (4 marks)

      ii. The mass flow rate of the steam (4 marks)

      iii. Heat rejection in the condenser (4 marks)

      iv. The thermal efficiency of the plant and compare it with Carnot cycle efficiency (4 marks)

Ghana

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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

MATHEMATICS

- **TIME ALLOWED - THREE HOURS**
- **Answer SIX questions only**
- **Date:** **Pass marks: 50%**

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

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1.

a. Find the constants A, B and C such that:

$$x^2+3x-4 \equiv A(x-1)(x+3)+B(x-1)+C(x+3)$$ **(6 Marks)**

b. Determine the range of values of k for which the quadratic equation

$kx^2+6(k-2)x+3(k+1)=0$ has real distinct roots **(6 Marks)**

c. The roots of the equation $x^2+2px+q=0$ differ by 2. Show that $p^2=1+q$. Hence find the roots of the equation in terms of p **(8 Marks)**

2.

a. Resolve into partial fractions

i. $\dfrac{x+1}{(x-1)(2x+1)}$ **(5 Marks)**

ii. $\dfrac{x}{(x+1)(x^2+1)}$ **(5 Marks)**

b. Show that $x-2$ is a factor of x^3+3x^2-6x-8 and hence find the factors of the expression. **(5 Marks)**

c. Solve the inequality $x^2-3x \leq 10$. **(5 Marks)**

3.

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

$$x - y + 2z = 4$$
$$-x + 2y + z = 1$$
$$x + 3y - z = 2$$

(10 Marks)

b. If $A = \begin{pmatrix} -1 & 2 & 1 \\ 4 & -3 & 2 \\ 2 & 1 & -1 \end{pmatrix}$, determine

i. Determinant of A **(2 Marks)**

ii. Cofactor matrix of A and Adjoin matrix of A **(6 Marks)**

iii. Inverse matrix of A **(2 Marks)**

4.

a. Find the complex number z such that $\frac{z+3i}{\overline{z}+3i} = 2i$ where $z = x + iy$, $\overline{z} = x - iy$ and $i = \sqrt{-1}$

(8 Marks)

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

i. $z_1 + 2z_2 - z_3$

ii. $z_1 \times (2z_2 + z_3)$

iii. $\frac{-iz_1 + 2z_3}{2z_2}$

(12 Marks)

Hint: $r\angle\theta \equiv r(Cos\,\theta + i\,Sin\,\theta)$

5.

a. Integrate the followings

i. $\int \frac{1 + Co\sec^2 x}{x - \cot x} dx$ **(5 Marks)**

ii. $\int \frac{x+7}{(x+2)(x+3)} dx$ **(5 Marks)**

iii. $\int_0^1 x \tan^{-1} x \, dx$ **(5 Marks)**

b. The curve C has equation $y = x^2 + 2$. The finite region bounded by C, the line x = 0 and x = 2 is rotated through 2π radians about the x-axis. Find the volume of the solid generated.

(5 Marks)

6.

c. If $x = Cost$ and $y = Sin t$,

i. Show that $y^3 \frac{d^2y}{dx^2} + 1 = 0$ **(5 Marks)**

ii. Determine $\frac{d^2y}{dx^2}$ when $t = \pi/2$ **(5 Marks)**

d. If $y = \sin\sqrt{x}$, show that $4x\frac{d^2y}{dx^2} + 2\frac{dy}{dx} + y = 0$ **(10 Marks)**

7. The function $f(x) = \frac{x(x^2-1)}{x-1}$

a. Write down the singular points of f(x) **(2 Marks)**

b. Determine $\lim_{x\to+\infty} \frac{x(x^2-1)}{x-1}$ and $\lim_{x\to-\infty} \frac{x(x^2-1)}{x-1}$ **(6 Marks)**

c. Find $\frac{dy}{dx}$ and $\frac{d^2y}{dx^2}$ **(6 Marks)**

d. Determine the nature of the turning points. **(6 Marks)**

8.

a. Prove the following identities

i. $\frac{Sin2x}{1+Cos2x} = Tan\,x$ **(4 Marks)**

ii. $\frac{1-Sin2x}{Cos\,2x} = \frac{Cos\,x - Sin\,x}{Cos\,x + Sin\,x}$ **(4 Marks)**

b. Given that $Tan\frac{x}{2} = t$

i. Express $Sin\,x, Cos\,x$ and $Tan\,x$ in terms of t. **(6 Marks)**

ii. Express $3Cos\,x + 2Sin\,x$ in terms of t. Hence solve the equation $3Cos\,x + 2Sin\,x = 3$

(6 Marks)

9.

a. Show that $\int_0^1 \frac{1}{1+x}dx = \ln 2$ **(5 Marks)**

b. Use 1/3 Simpson's rule to interpolate a value for the integration $\int_0^1 \frac{1}{1+x}dx$ for ~~five~~ twenty ordinates (n = 20). (10 marks)

c. Hence determine the value of ln 2 for four decimal places. **(5 Marks)**

Library

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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 Four (04) Questions From Part A, and Two(2) Questions From Part B.***
- **Date:**

Pass Mark 50%

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

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Part A

1. a) Express Lenz's law and Faraday's laws. **(06 Marks)**

   b) A long solenoid has 400 turns wound on a cylinder of magnetic material with $\mu_r = 1700$, with radius 0.80 cm and length 7.0 cm. **(08 Marks)**

   i. Calculate the inductance of the coil.

   ii. If the current in the coil increases at the rate of $0.753\ As^{-1}$ find the induced voltage.

   c) When two coils are connected in series, their effective inductance is found to be 10 H. When the connections of one coil are reversed, the effective inductance is 6 H. If the coefficient of coupling $k = 0.6$ and mutual inductance given by $M = k\sqrt{L_1 L_2}$, calculate the self-inductance of each of coil and the mutual inductance. **(06 Marks)**

2. a) i. Define magnetic field. **(04 Marks)**

   ii. Draw the pattern of the magnetic field produced by electric current through a straight wire and through a wire coil. **(06 Marks)**

   b) In the magnetic circuit detailed in Figure 1 with all dimensions in mm, calculate the required current to be passed in the coil having 200 turns in order to establish a flux of 1.28 mWb in the air gap. Neglect fringing effect and leakage flux. The B-H curve of the material is given in Figure 2. Permeability of air may be taken as $\mu_o = 4\pi \times 10^{-7}\ H/m$.

(10 Marks)

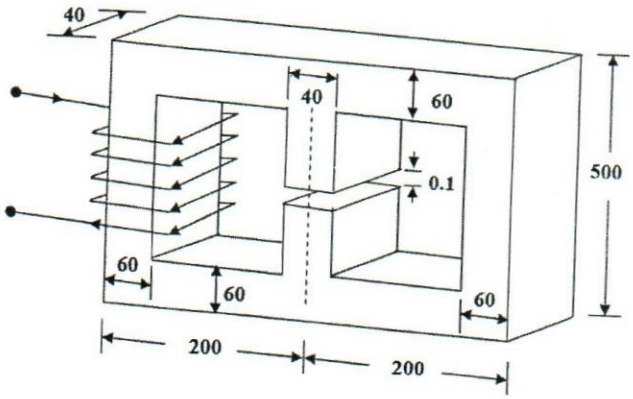


Figure 1

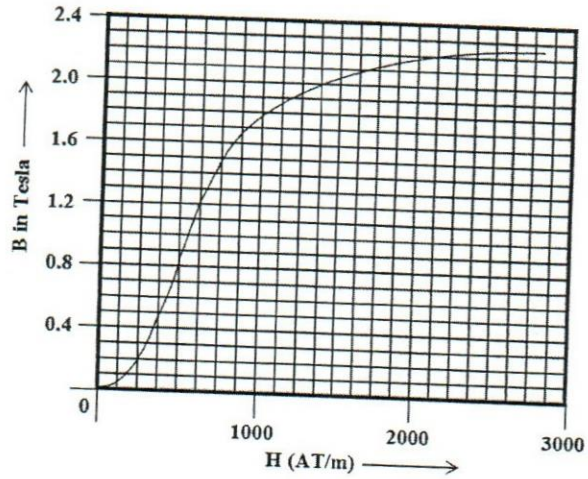
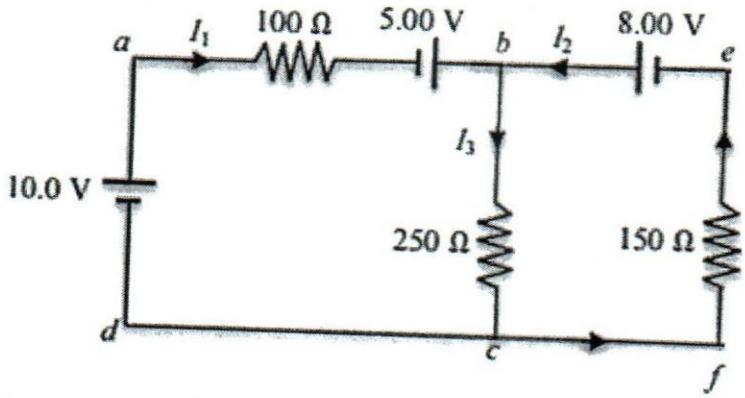


Figure 2

3. a) Express Kirchhoff current and voltage laws. **(06 Marks)**

b) Consider the DC circuit shown in below and note that the direction of the currents shown in the figure are arbitrary. (8 marks)

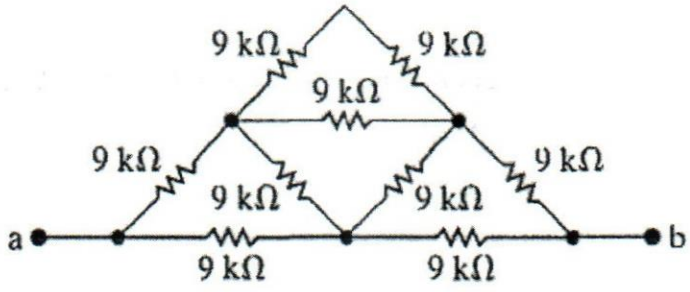


i. Find each branch current.

ii. What is the direction of the current through 250 Ω resistor? (from b to c or from c to b)

iii. Determine the potential difference Va – Ve, with the appropriate sign.

c) Using star delta transformation find equivalent resistance between a and b. **(06 Marks)**



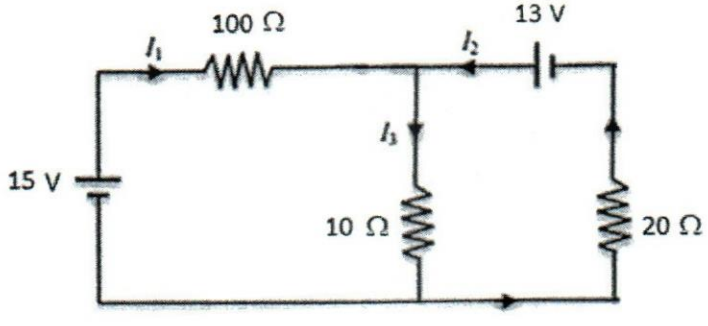
4. a) Define ideal voltage source and ideal current source. **(06 Marks)**

b)

i. Draw schematic circuit diagrams for the real voltage source and the real current source.

ii. If the real voltage source and real current source are equivalent, express current through current source in terms of e.m.f (E) and internal resistance (R_{int})of voltage source. **(06 Marks)**

c) Find the current in various resistors in the circuit shown in below, by converting voltage sources into currents sources. **(08 Marks)**



5. a) Draw the equivalent circuit of a DC shunt motor and develop the torque-speed characteristics using basic equations. **(06 Marks)**

armature resistance 1.25Ω

b) 100V, 1kW DC shunt motor with a variable field resistance rotates at 600rpm and draws a current of 1A at no load. Given that the field resistance is reduced by 50% at full load, Calculate

i. Armature current **(06 Marks)**
ii. Torque and speed **(04 Marks)**
iii. Efficiency **(04 Marks)**

6. A series RLC circuit with $R = 10.0\ \Omega$, $L = 400\ mH$ and $C = 2.0\ \mu F$ is connected to an AC voltage source which has a maximum amplitude $V_0 = 100\ V$.

a) What is the resonant frequency? **(07 Marks)**
b) Find the r.m.s current at resonance. **(07 Marks)**
c) Let the driving frequency be $\omega_0 = 4000\ rad/s$. Compute X_C, X_L, Z and ϕ. **(06 Marks)**

Part B

7. a. Explain under what conditions fuses can be used and they cannot be used to protect electrical distribution system. **(04 Marks)**
b. Explain in detail why reverse power protection is required when alternators are load shearing. **(06 Marks)**
c. Explain with a diagram a construction and the function of a device used for reverse power protection. **(10 Marks)**

8. a. State what conditions are needed to be satisfied to synchronize two or more alternators to a common bus bar and how they can be achieved. **(06 Marks)**
b. Explain how kW and kVAr loads are regulated and shared between the alternators. **(06 Marks)**
c. Explain with aid of diagram AVR suitable for regulation the voltage of a alternator used for ship board duties. **(08 Marks)**

9. (a) Explain with a aid of a diagram how Fluorescent tubes are started and explain how power factor is improved. **(08 Marks)**
(b) Explain the dangers which may exist in Battery rooms and explain how they are overcome. **(06 Marks)**
(c) Explain with a aid of a diagram how shipboard batteries are connected for recharging. **(06 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

Maritime Law

- **TIME ALLOWED - THREE HOURS**
- **Answer SIX questions only**
- **Date: 2019.06.03** **Pass marks: 50%**

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

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1. Write Short notes on following;
   a. International Maritime Organization (04 Marks)
   b. Flag State (04 Marks)
   c. Coastal State (04 Marks)
   d. Port State (04 Marks)

2. Referring to Risk Management on board ships, briefly define following terms;
   a. Hazards (03 Marks)
   b. Risk. (03 Marks)
   c. Risk Assessment. (03 Marks)
   d. Control Measures (03 Marks)
   e. List 02 numbers of hazard that could encounter when overhauling an Auxiliary Boiler Water Gauge Glass and briefly explain the control measures could be used to mitigate the risk from those hazards. (04 Marks)

3. With reference to the Convention on "Law of the Sea" (UNCLOS), briefly explain the Rights, Responsibilities and authorities of a State at each of following sea areas.
   a. Territorial sea (04 Marks)
   b. Contiguous Sea (04 Marks)
   c. Exclusive Economic Zone (04 Marks)
   d. High sea (04 Marks)

4. Certificates are issued to merchant ships to indicate their compliance with International, National & Classification Regulations & Rule requirements.
   a. State five (05) parties interested in ship certification. (05 Marks)

b. State the main areas covered by the "Certificate of Class" issued to a ship by a classification society. (05 Marks)
c. What is mean by "Statutory Certificates". (02 Marks)
d. State 04 advantages of Harmonized System of Survey & Ship Certification. (04 Marks)

5. As per the Marpol convention of IMO

a. State the requirement in Marpol Annex I with regard to equipment to be used for pumping out M/C space bilges, while in special areas on any ship. (05 Marks)
b. What are the categories of hazardous Cargo as per the Marpol Annex II. (03 Marks)
c. State the type of sewage systems that could be installed on sea going ships to comply with Marpol Annex IV requirements. (03 marks)
d. What are the requirements stated in Marpol Annex IV, for discharging sewage in to sea from sea going vessel? (05 Marks)

6. Referring to Marpol Annex VI;
a. State the certificates required to be carried on board ships. (05 Marks)
b. In addition to above state 05 other relevant documents required to carry on board ships. (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. SOLAS Chapter IX - ISM code introduce to the maritime industry by IMO in 1998.
a. What is the main purpose of introducing the code. (03 Marks)
b. What is meant by "Critical equipment" or "Critical Systems" as per the above code. (04 Marks)
c. Briefly explain the procedures to be followed, stating the documents to be checked, during takeover of duties as an officer In-charge of a watch after Joining a ship. (09 Marks)

8. With reference to the Convention on STCW with particular emphasis on the 2010 Manila Amendments:
a. State most significant seven (07) amendments carried out to STCW during Manila 2010 convention. (07 Marks)
b. What is the Rest Hours & Work Hours requirement for seafarers according to the new amendments to the STCW? (04 Marks)
c. What is the minimum age for a seafarer and the regulations applied for that "Young" seafarer as per Maritime Labour Convention 2006? (05 Marks)

9. Polar Code has been introduced to mitigate the risks encountered to ships operating in polar waters.
a. State 05 specific hazards identified for vessels operating in polar areas. (05 Marks)
b. State the different ship categories define under this Code? (03 Marks)
c. State exemptions that may be granted by the administration for existing ships operating in polar waters under polar Code? (05 Marks)
d. What are the essential documents required to be carried on board ships which are subjected to control under this code. (03 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: 2019.05.31** **Pass marks: 50%**

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

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

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***

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1. A gas has a density of ***1.875 kg/m^3*** at a pressure of ***1 bar*** and with a temperature of ***15 ^{0}C***. The density of the gas has been changed to ***2 kg/m^3*** by introducing additional mass of gas and let the gas to reach initial temperature. A mass of ***0.9 kg*** of the gas requires a heat transfer of ***175 kJ*** to raise its temperature from ***15 ^{0}C*** to ***250 ^{0}C*** while the pressure of the gas remains constant. Determine
   a. The gas constant and the final pressure (6 marks)
   b. The specific heat capacity of the gas at constant pressure and constant volume (6 marks)
   c. The change of internal energy (4 marks)
   d. The work transfer (4 marks)

2. A wall made up of two layers of bricks ***100 mm*** and ***150 mm*** thick with a ***20 mm*** air space between them. The wall is ***6 m*** long and ***5 m*** high. The coefficients of thermal conductivity of inside brick, outside brick and air ***0.6 , 0.8*** and ***0.025 W/m K*** respectively.
   a. Determine
      i. The ***overall heat transfer coefficient*** in ***W/ m^2 K***. (4 marks)
      ii. The ***heat loss per hour*** through the wall if the inside face temperature is ***24 ^{0}C*** and the outside face temperature is - ***14 ^{0}C*** (4 marks)
      iii. The ***interface temperatures*** (8 marks)
   b. Sketch the temperature variation across the composite wall (4 marks)

3. In an ideal constant volume cycle (***Otto cycle***), the pressure and temperature of the air at the beginning of compression are ***0.97 bar*** and ***50 ^{o}C*** respectively. The ratio of compression is ***5:1***. The heat supplied during the cycle is ***970 KJ/kg*** of the working fluid. Determine:

   a. Maximum temperature of the cycle. (8 marks)

   b. Thermal efficiency of the cycle. (6 marks)

   c. Work done during the cycle per kg of working fluid (6 marks)

4. An engine uses air as the working substance. At the beginning of compression, the pressure is ***0.90 bar*** and the temperature is ***40 ^{0}C***. During the adiabatic compression, the volume is reduced to one sixteenth of its value of the beginning of compression stroke. Heat is then added at constant pressure until the temperature is ***1400 ^{0}C***. The stroke is completed by adiabatic expansion until the initial volume is reached, and a constant volume closes the cycle.

   a. Sketch the ***P – V*** diagram for the engine. (2 marks)

   b. Calculate the pressure and temperature at all point of the cycle. (12 marks)

   c. Determine the thermal efficiency of the cycle. (6 marks)

5. Steam at a pressure of ***40 bar*** and temperature of ***400 ^{0}C*** is fed into a steam turbine from a boiler. In the turbine the steam is expanded isentropically to pressure of ***0.4 bar***. The steam is then exhausted into a condenser where it is condensed but not under cooled. The condensate is then pumped back into the boiler. Determine

   a. Draw the ***T-S*** diagram (4 marks)

   b. Determine

      i. Dryness fraction of the steam after expansion (4 marks)

      ii. The mass flow rate if the power output of the turbine is ***100 MW*** (4 marks)

      iii. The Rankine efficiency (4 marks)

      iv. The mass of coal supplied per hour if the boiler thermal efficiency is ***85%*** (4 marks)

   Hint: Calorific value of the coal used in the boiler is ***34.5 MJ/kg***

6.

   a. What is ***calorific value*** of the fuel? What is the difference between ***HCV*** and ***LCV***? (4 marks)

   b. A fuel oil consists of the following percentage analysis by mass.

      C - 82%; H_2 - 12%; O_2 - 2% ; S - 1% ; N_2 - 3%.

i. Determine ***stoichiometric*** mass of air required to completely burn the fuel. (9 marks)

ii. Determine the ***products*** of combustion by mass as percentage. (7 marks)

7. A single stage, single-acting, reciprocating air compressor has a bore and stroke of ***180 mm.*** the clearance volume is ***5%*** of the swept volume and the speed is ***6.8 rev/s***. The air intake pressure is ***100 kPa*** and the delivery pressure is ***600 kPa***. The polytropic index is ***1.25*** throughout. Determine

   a. The theoretical volumetric efficiency referred to intake conditions (6 marks)
   b. The volume of air delivery per second (6 marks)
   c. The air power of the compressor. (8 marks)

8. The test bed results for a naturally aspirated, six cylinders, two stroke compression ignition engine with a bore of ***900 mm*** and stroke of ***2000 mm*** are as follows

   Test speed ***90 rev/min***
   Fuel net calorific value ***42 MJ/kg***
   Consumption ***1650 kg/h***
   Brake torque on the shaft ***1250 kNm***
   Average indicated mean effective pressure for the engine ***14.1 bar***

   Determine

   a. Indicate power (3 marks)
   b. Brake power and mechanical efficiency (5 marks)
   c. Brake thermal efficiency and indicated thermal efficiency (6 marks)
   d. The brake specific fuel consumption and indicated specific fuel consumption (6 marks)

9. A ***Freon -12*** refrigerating machine operates the ideal vapour compression cycle between the limits ***-15 ^{0}C*** and ***30 ^{0}C***. The vapor is dry saturated at the end of isentropic compression and there are no under-cooling of the condensate in the condenser.

   a. Calculate

      i. The dryness fraction at the suction of the compressor (4 marks)
      ii. The refrigerating effect per kg of refrigerant (4 marks)
      iii. The coefficient of performance (4 marks)
      iv. The Carnot coefficient of the performance (4 marks)

   b. Draw the ***T-S*** diagram (4 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: 2019.05.30** **Pass marks: 50%**

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

1. A quadratic function is defined by $f(x) = -2x^2 + 4x + 6$.

   a. Find the set of values of x for which $f(x) > 8$. (5 marks)

   b. Find the set of values of k for which $f(x) = k\,x$ has no real roots. (5 marks)

   c. By considering the identity $-2x^2 + 4x + 6 = A(x + B)^2 + C$, where A, B and C are constants, find the greatest value of $f(x)$. (5 marks)

   d. Sketch the curve $y = f(x)$, showing any intercept with the coordinates axes. (5 marks)

2.

   a. Prove that:

      i. $\text{Sin}\,(A + B)\,\text{Sin}(A - B) = (\text{Sin}\,A - \text{Sin}\,B)\,(\text{Sin}\,A + \text{Sin}\,B)$ (4 marks)

      ii. $\text{Sin}\,(2A - 2B)\,\text{Cos}\,2B + \text{Cos}\,(2A - 2B)\,\text{Sin}\,2B = 2\,\text{Sin}\,A\,\text{Cos}\,A$ (4 marks)

   b. Solve the equation $\text{Cos}\,4x + \text{Cos}\,2x = \text{Cos}\,3x$ for $0^0 \leq x \leq 360^\circ$. (7 marks)

   c. If A is in the first quadrant and $\sin A = \frac{5}{13}$, B is in the fourth quadrant and $\cos B = \frac{4}{5}$. Find $\tan\,(A + B)$ without using a calculator. (5 marks)

3.

   a. Represent the following complex numbers in an Argand diagram

      i. $\frac{1-2i}{3+4i}$ (3 marks)

      ii. $\frac{2\angle -\pi/6}{1\angle \pi/3}$ (3 marks)

b. Convert the following complex numbers into rectangular form

i. $\left(2\angle \pi/6\right)\left(1\angle -\pi/3\right)$ (4 marks)

ii. $\dfrac{2\angle \pi/4}{1\angle -\pi/4}$ (4 marks)

c. Find the square root of 1+ 2i (6 marks)

Hint: $r\angle\theta \equiv r\left(\text{Cos}\theta + i\,\text{Sin}\theta\right)$

4. If $A = \begin{pmatrix} 3 & -3 & 4 \\ 2 & -3 & 4 \\ 0 & -1 & 1 \end{pmatrix}$

a. Find the Adjoint of A. (7 marks)

b. Find the Inverse of A. (7 marks)

c. Hence show that $A^3 = A^{-1}$ (6 marks)

5.

a. Solve $2\log(3x-2) - 2\log(2x-1) = \log(x-1)$. (5 marks)

b. If $a = \log_e(e^2)^2$, $b = \frac{1}{3}\log_e(e^3)$ and $b = 3\log_e(e^3)$, find. (4 marks)

c. Solve the simultaneous equation

$$4^{\left(\frac{x-1}{2}\right)} - 5^{(y-3)} = 25$$

$$2^{(x-1)} + 5^{(y-2)} = 50$$ (5 marks)

d. Determine the partial fractions of $\dfrac{3x^2+5x+3}{(x+2)(x^2+1)}$ (6 marks)

6.

a. Estimate the value of $\int_0^1 \dfrac{1}{1+x^2}\,dx$ (5marks)

b. Use 1/3 Simpson's rule to interpolate a value for the integration $\int_0^1 \dfrac{1}{1+x^2}\,dx$ for ten ordinates (h = 0.1). (10 marks)

c. Hence determine the value of π for four decimal places. (5 marks)

b. Convert the following complex numbers into rectangular form

i. $\left(2\angle \pi/6\right)\left(1\angle -\pi/3\right)$ (4 marks)

ii. $\dfrac{2\angle \pi/4}{1\angle -\pi/4}$ (4 marks)

c. Find the square root of 1+ 2i (6 marks)

Hint: $r\angle\theta \equiv r\left(\text{Cos}\theta + i\,\text{Sin}\theta\right)$

4. If $A = \begin{pmatrix} 3 & -3 & 4 \\ 2 & -3 & 4 \\ 0 & -1 & 1 \end{pmatrix}$

a. Find the Adjoint of A. (7 marks)

b. Find the Inverse of A. (7 marks)

c. Hence show that $A^3 = A^{-1}$ (6 marks)

5.

a. Solve $2\log(3x-2) - 2\log(2x-1) = \log(x-1)$. (5 marks)

b. If $a = \log_e(e^2)^2$, $b = \frac{1}{3}\log_e(e^3)$ and $b = 3\log_e(e^3)$, find. (4 marks)

c. Solve the simultaneous equation

$$4^{\left(\frac{x-1}{2}\right)} - 5^{(y-3)} = 25$$

$$2^{(x-1)} + 5^{(y-2)} = 50$$ (5 marks)

d. Determine the partial fractions of $\dfrac{3x^2+5x+3}{(x+2)(x^2+1)}$ (6 marks)

6.

a. Estimate the value of $\int_0^1 \dfrac{1}{1+x^2}\,dx$ (5marks)

b. Use 1/3 Simpson's rule to interpolate a value for the integration $\int_0^1 \dfrac{1}{1+x^2}\,dx$ for ten ordinates (h = 0.1). (10 marks)

c. Hence determine the value of π for four decimal places. (5 marks)

7.

a. Differentiate the following functions with respect to x

i. $y=\left(x^2+1\right)^2\left(2x-1\right)$ (4 marks)

ii. $y=e^{x\mathrm{Sin}\,x}+e^{x^2}\,\mathrm{Sin}\,x$ (4 marks)

iii. $y=\dfrac{\mathrm{Sin}\,x-\mathrm{Cos}\,x}{1+\mathrm{Cos}\,x}$ (4 marks)

b. Describe the nature of stationary values of the function, $y=\dfrac{2-3x}{x^2+2}$. Hence, plot the function. (8 marks)

8.

a. Evaluate

(i) $\int 2\mathrm{Sin}\,x+\mathrm{Cos\,ec}^2\,x\,dx$ (ii) $\int\dfrac{2}{x}-\dfrac{3}{9+4x^2}dx$ (iii) $\int\dfrac{2x}{x^2+x+12}dx$

(9 marks)

b. Find the area of the region R bounded by $y=\sqrt{1-x^2}$ and $y=0$. (5 marks)

c. If R is rotating around X axis, find the volume of the solid of revolution. (6 marks)

9.

a. Determine the partial differentiation, $\dfrac{\partial f}{\partial x},\dfrac{\partial f}{\partial y}$ each of the following functions

i. $f(x,y)=x^3-2y^2$ (4 marks)

ii. $f(x,y)=3x^2y^2+2xy^3$ (4 marks)

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

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

ii. $x^2\dfrac{\partial^2 u}{\partial x\partial y}+2\dfrac{\partial^2 u}{\partial y^2}=0$ (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

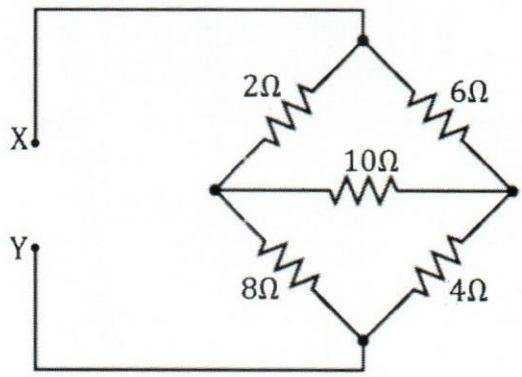
- **TIME ALLOWED - THREE HOURS**
- **Answer ANY FOUR questions from part A and ANY TWO questions from part B**
- **Date: 2019.05.29** **Pass marks: 50%**

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

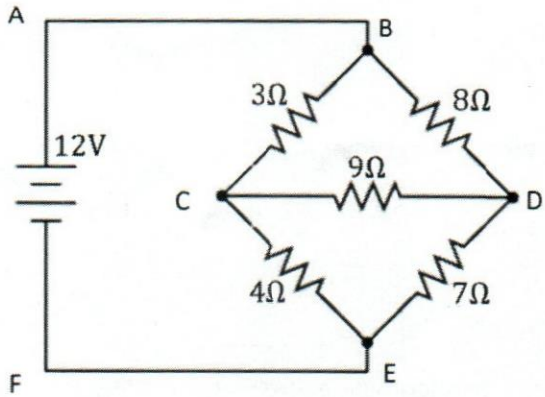
Part A

1. a) Express Kirchhoff's current and voltage laws. (04 marks)

   b) Find the equivalent resistance between X and Y using Delta-Star $(\Delta \leftrightarrow Y)$ transformation. (06 marks)



   c) Calculate the currents in the various branches of the network given below. (10 marks)

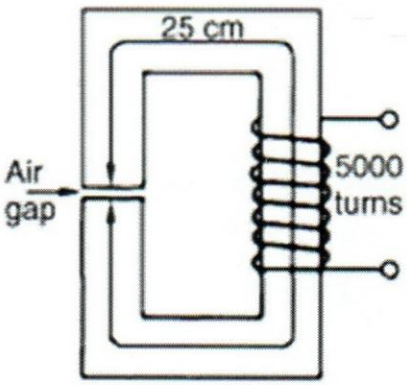


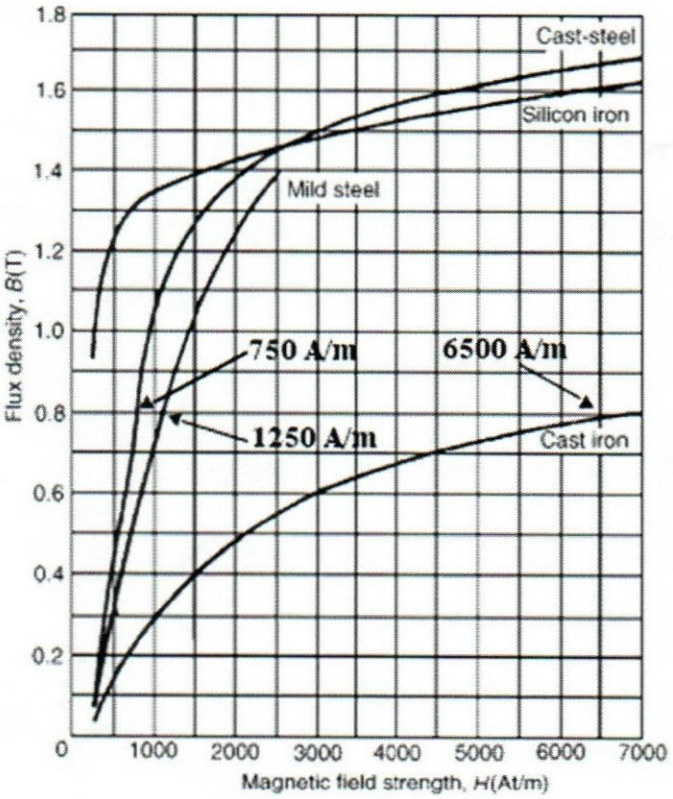
2. a) A mild steel ring has a mean radius of 50 mm and a cross sectional area of 400mm^2. A current of 0.5A flows in a coil wound uniformly around the ring and flux produced is 0.1 mWb. If the relative permeability and permeability of air are 200 and $4\pi \times 10^{-7} H/m$, find the

   i. Reluctance of the mild steel (05 marks)

   ii. Number of turns in the coil (05 marks)

   b) A section through a magnetic circuit of uniform cross-sectional area 2cm^2 is shown in below figure. The cast steel core has mean length of 25 cm. the air gap is 1 mm wide and the coil has 5000 turns. Determine the current in the coil to produce a flux density of 0.8 T in the air gap, assuming that all the flux passes through both parts of the magnetic circuit. (10 marks)





B–H curves for four materials

3. a) Draw schematic circuit diagrams of D.C. shunt motor and D.C. series motor. (06 marks)

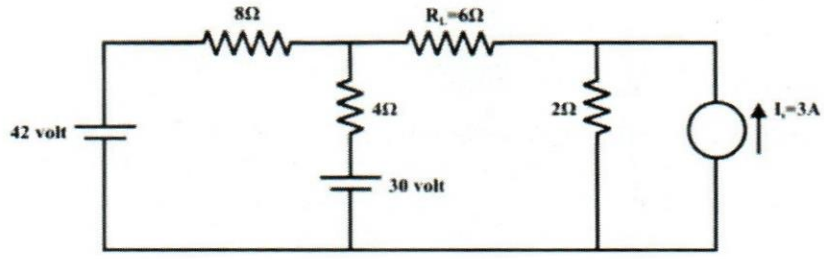
   b) A 230V shunt motor takes 5A at no load. The resistance of armature and field circuit are 0.25 Ω and 115 Ω respectively. If the motor is loaded so as to carry 40A, Determine

   i. Iron and frictional losses. (06 marks)

   ii. commercial efficiency (08 marks)

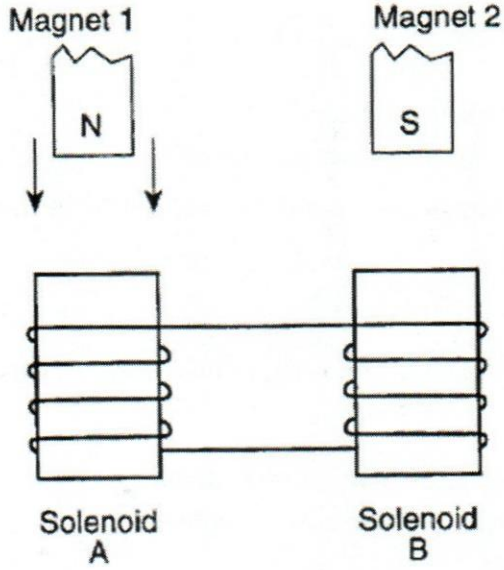
4. a) A length of wire has a resistance of 4.5 Ω. Find the resistance of another wire of the same material three times as long and twice the cross-sectional area. (06 marks)

   b) If internal resistance of current source is infinity and all voltage source are ideal, find the current I_L through 6 Ω resistor using Thevenin's theorem or otherwise. (14 marks)



5. a) State Faraday's laws of electromagnetic induction with relevant equation. (04 marks)

   b) If the north pole of magnet 1 is dropped through solenoid A, state the response of the south pole of magnet 2. (04 marks)



   c) A wooden ring type toroid of mean diameter 400 mm and cross-sectional area 400mm^2 is uniformly wound with a coil of 1000 turns which carries a current of 2A. Given that relative permeability of wood is 1 and permeability of air $\mu_0 = 4\pi \times 10^{-7}\, H/m$.

   Determine

   i. Self-inductance of coil (08 marks)

   ii. The e.m.f induced in the coil when the current is uniformly reduced to zero in 2 ms.

   (04 marks)

6. A series RLC circuit with resistance of 50Ω, inductance of 600mH and capacitance of 30μF is connected to an AC voltage source which has peak to peak amplitude Vp-p=100V and 50Hz operating frequency. Calculate

a)

i. Calculate the inductive reactance (03 marks)

ii. Calculate the capacitive reactance (03 marks)

iii. Calculate the circuit impedance (03 marks)

iv. Calculate the total current with reference to the supply voltage (03 marks)

b)

i. Express the term "Resonance Frequency" of a RLC circuit (03 marks)

ii. Calculate the resonant frequency for above mentioned circuit (03 marks)

iii. Find the total current flowing through circuit with reference to the supply voltage (02 marks)

Part B

7. With reference to protection devices:

a) Why protection devices are essential for motors? (04 marks)

b) Briefly explain the reasons for overheating of motors. (05 marks)

c) What are the protection devices fitted in motors? (05 marks)

d) What is the purpose of having a time lag in motor overload trips? (02 marks)

e) Briefly explain the meaning of inverse time characteristic of protection relay. (04 marks)

8. With reference to electrical distribution systems:

a) Explain why it is normal marine practice not to earth the neutral point of 3-ph A.C generators. (05 marks)

b) Explain advantages and disadvantages of an insulated neutral system. (07 marks)

c) State how a single earth fault is indicated on a ship whose 3-ph A.C generators have insulated neutral system. (08 marks)

9. a) Explain construction details and the function of each major components in two types of AC 3 - phase motor used in shipboard practice. (10 marks)

b) Explain with aid of a diagram on a starting method that can be used in any of the above motors (10 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 SIX questions only**

Date: 2019.05.28 **Pass marks: 50%**

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

---

1.

1.1 Two speed boats A and B starts from the same place "O" with velocities 24km/h and 16km/h at the same time and travel with constant velocity in the same direction. The boat A, after travelling 16km hit an iceberg and suddenly stops. Then it rests for 10 minutes and returns towards "O" with constant velocity of 20km/h while the boat B continue to travel forward with its original constant velocity.

a. Draw Displacement vs. time and Velocity vs. time graphs for motions of both boats in the same graph. **(8 Marks)**
b. Find the distance from "O" to the place where they meet **(6 Marks)**
c. Find the time at which they meet each other **(6 Marks)**

2.

2.1 Two partials P and Q of masses 3kg and 6kg respectively are attached to the ends of a light inextensible string passing over a fixed smooth pulley. When both particles are 15m above the horizontal ground, the system is released from rest.

a. Find the time taken by the particle Q to fall to the ground. **(4 Marks)**
b. Assuming that the particle P does not reach the pulley, find the maximum height ascended (go up) by P after Q hit the ground **(6 Marks)**
c. Considering the motion of P, calculate the time which the particle Q begins to move again? (Assume the ground to be inelastic) **(10 Marks)**

3.

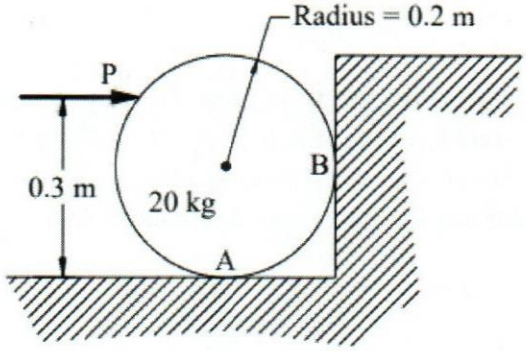
3.1 A plate clutch has three discs on the driving shaft and two discs on the driven shaft, providing four pairs of contact surfaces. The outside diameter of the contact surfaces is 240 mm and inside diameter 120 mm. Assuming uniform pressure and $\mu = 0.3$, find the total spring load pressing the plates together to transmit 25 kW at 1575 rpm. **(14 Marks)**

3.2 If the total spring force reduced by 780N due to wear of the plates, find the maximum power that can be transmitted at 1575 rpm (assume uniform wear). **(06 Marks)**

4

4.1 Differentiate Static friction vs. Dynamitic friction. **(05 Marks)**

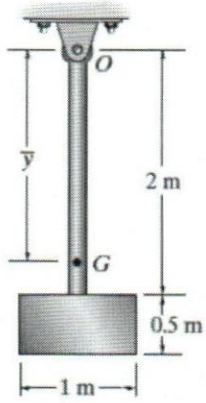
4.2 The cylinder is initially at rest when a horizontal force P is applied. The coefficients of static friction at A and B are $\mu_A = 0.3$ and $\mu_B = 0.6$. Determine the minimum value of P that will cause the cylinder to move. **(15 Marks)**



5.

5.1 State and prove parallel axis theorem **(06 Marks)**

5.2 The pendulum consists of the 3-kg slender rod and the 5-kg thin plate. Determine the location y of the center of mass G of the pendulum; then calculate the moment of inertia of the pendulum about an axis perpendicular (normal) to the page and passing through G. **(14 Marks)**



6.

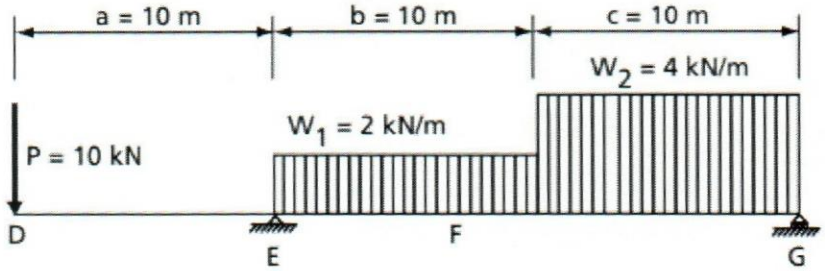
6.1 Describe the idea of "mass moment of inertia" and state its units **(4 Marks)**

6.2 A solid cylindrical pulley of mass 800kg, having 0.8m radius of gyration, and 2m diameter, is rotating by an electric motor, which exerts a uniform torque of 60kNm. A body of mass 3 Tons is to be lifted by a wire wrapped round the pulley. Find;

a. acceleration of the body **(8 Marks)**
b. tension in the rope **(8 Marks)**

7.

7.1 The distribution of loads in a simply supported beam is as given in the diagram below. Determine the reactions at the supports and draw the shear-force and bending moment diagram. **(20 Marks)**



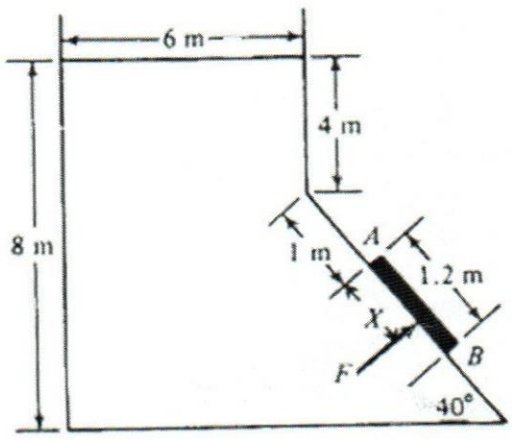
8.

8.1 State Bernoulli equation and identify the variables **(4 marks)**

8.2 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 flow rate through the pipe is noted to be 6 m^3/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 noted to be from A to B. **(16 marks)**

9.

9.1 At a water reservoir, Gate AB in the figure is 1.2 m long and 0.8 m wide. Calculate force F on the gate and its center of pressure position (value of X). **(20 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

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: 2019.05.27** **Pass marks: 50%**

Part A: NAVAL ARCHITECTURE

1. The half ordinates at the summer draft of a 150m long ship are as follows.

Section	AP	½	1	1½	2	3	4	5	6	7	8	8½	9	9½	FP
½ Ordinates(m)	1.5	3.6	5.6	6.8	7.9	8.5	8.8	8.8	8.8	8.3	8.0	7.1	5.8	3.6	0

a. Calculate the area of the water plan at summer draft of the ship. (05 Marks)
b. Calculate the "Water Plan Area Coefficient" (C_w) of the ship. (03 Marks)
c. Find the Longitudinal Center of Floatation (LCF) of the ship at this draft. (08 Marks)

2.

a. Define Following terms with regards to transvers stability of a ship.
   I. Metacenter (02 Marks)
   II. Metacentric Height (02 Marks)

b. A ship of 4500 tonne displacement having initial KG of 4.5m. Following cargo is now loaded;

   450 tonnes at 7.5m Kg

   120 tonnes at 6.0m Kg

   650 tonnes at 3.0m Kg

   Find the mass of the cargo that has to be loaded at 6.0m Kg on tween deck level in order to adjust final metacentric height of the ship to 0.6m, assuming metacenter of the vessel at final loaded displacement is 5.6m above the keel. (12 Marks)

3.

a. Briefly explain the procedure of conducting Inclining Experiment for a ship. (03 Marks)

b. List five (05) conditions to be observed when preparing a vessel for Inclining Experiment. (05 Marks)

c. A ship of 65.0m long having a triangular cross section. The breadth at the water line is measured is 8.0m and the vessel is floating at 4.0m even keel draft. When a mass of 13 tonnes is shifted 6.0m across the ship it causes 20cm defection to a 3m long plumb line. Find the vertical center of gravity of the ship above the keel. (08 Marks)

4. A ship 120 m long has a light displacement of 1450 tonnes and LCG 3.24 m aft of mid-ship.

The following items are now loaded:
Cargo 2800 tonne, LCG 5.20 m forward of mid-ship
Fuel 120 tonne, LCG 35.50 m aft of mid-ship
Water 25 tonne, 36.25 m aft of mid-ship
Consumables 5 tonne, 38.0 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
6.0	4400	48.80	1.25 F	1.20 A

Calculate the final end drafts of the vessel. (16 Marks)

5. Resistance exerted by the water on a ship when moves through the water at a speed could be divided into two main components as Frictional Resistance & Residuary Resistance.

a. List the factors effecting the magnitude of each of above component. (06 Marks)
b. A 6.0 m mild steel model of a ship has a wetted surface area of 10.0 m^2 and when towed in Sea water at 03 knots, has a total resistance of 58 N. If the "Ship correlation Factor" (SCF) is 1.15, Calculate the effective power of a ship, 120 m long, at its corresponding speed. (10 Marks)

$f = 0.417 + \frac{0.773}{L+2.862}$ and $R_f = f S V^n$, n = 1.825 when V in Knots

6. i. Define following terms with respect to marine propellers;

a. Pitch (02 Marks)
b. Wake Speed (02 Marks)
c. Apparent Slip (02 Marks)
d. Real Slip (02 Marks)

ii. The Pitch Ratio (p) of the propeller of a 12,000 tonne displacement, 120m long & 17.2 m beam ship is 0.8 and the diameter (D) is 5.6 m. At 7.5m loaded draft, the main engine operates at MCR to rotate propeller at 120 RPM. The wake fraction $w = 0.5C_b - 0.05$ & the real slip is 35 %.

Calculate;

a. Speed of advance (04 Marks)
b. The speed of the ship (02 Marks)
c. Apparent slip (02 Marks)

II. PART B: SHIP CONSTRUCTION

7.

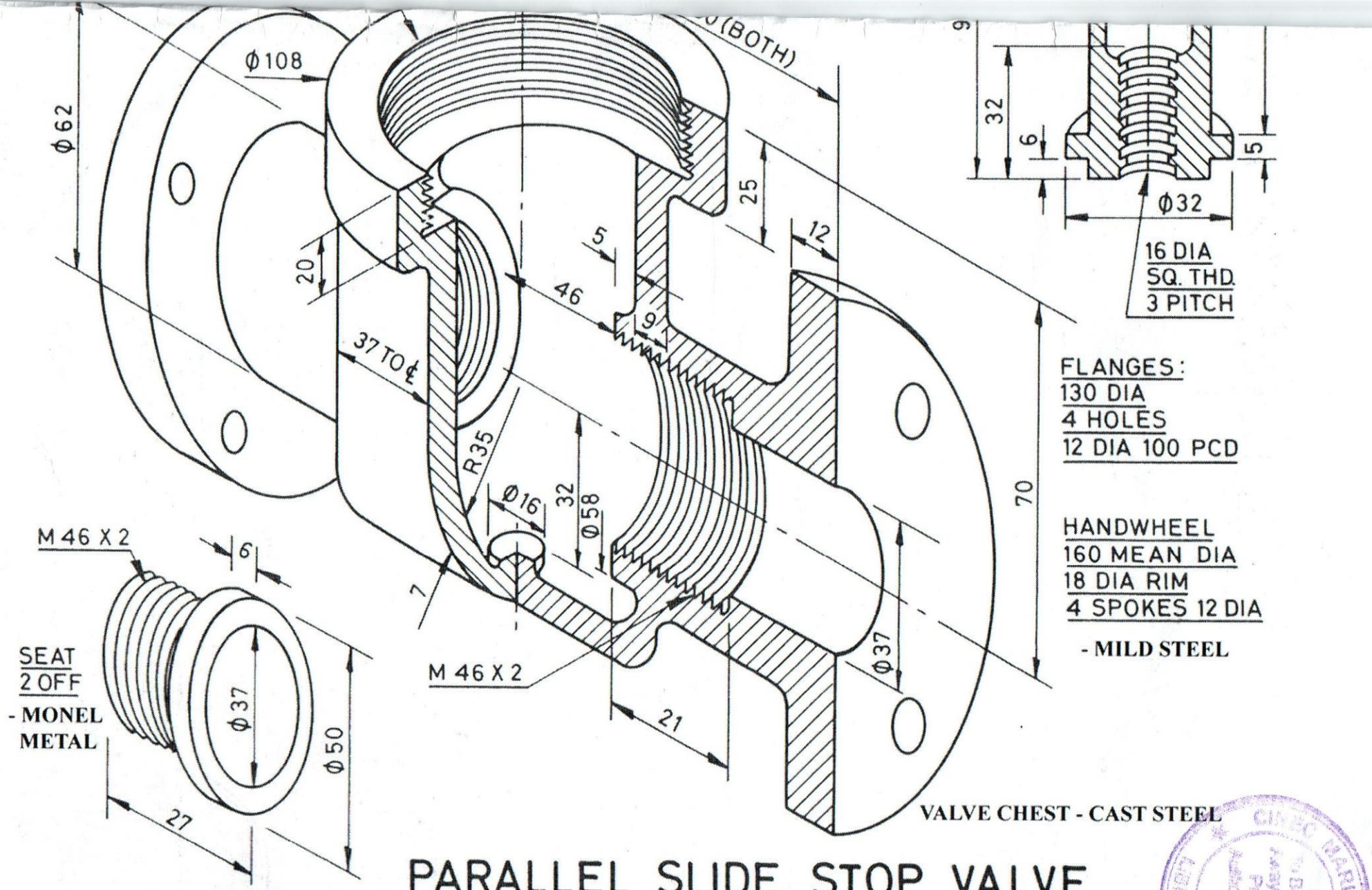
a. Sketch and describe the fore-end construction suitable for a large ship. (07 Marks)
b. With the aid of a simple sketch, explain how the fore-end is structurally strengthened to counter effect of
   i. Slamming (03 Marks)
   ii. Panting (03 marks)
c. Describe with a simple sketch the method used to secure the anchor cable to the chain locker? (03 Marks)

8.

a. Sketch and describe a hydraulically operated watertight door. (10 marks)
b. State the routine maintenance & test carried out to assure the operation of the door in compliance with the applicable requirements. (06 marks)

9. With reference to rudders

a. State different types of rudders with simple sketch showing the method of their attachment to the stern frame. (08 marks)
b. With the development of double plated rudder what is the advantage over single plated rudder (04 marks)
c. State the advantages of balanced rudder over other types of rudders. (04 marks)



PARALLEL SLIDE STOP VALVE

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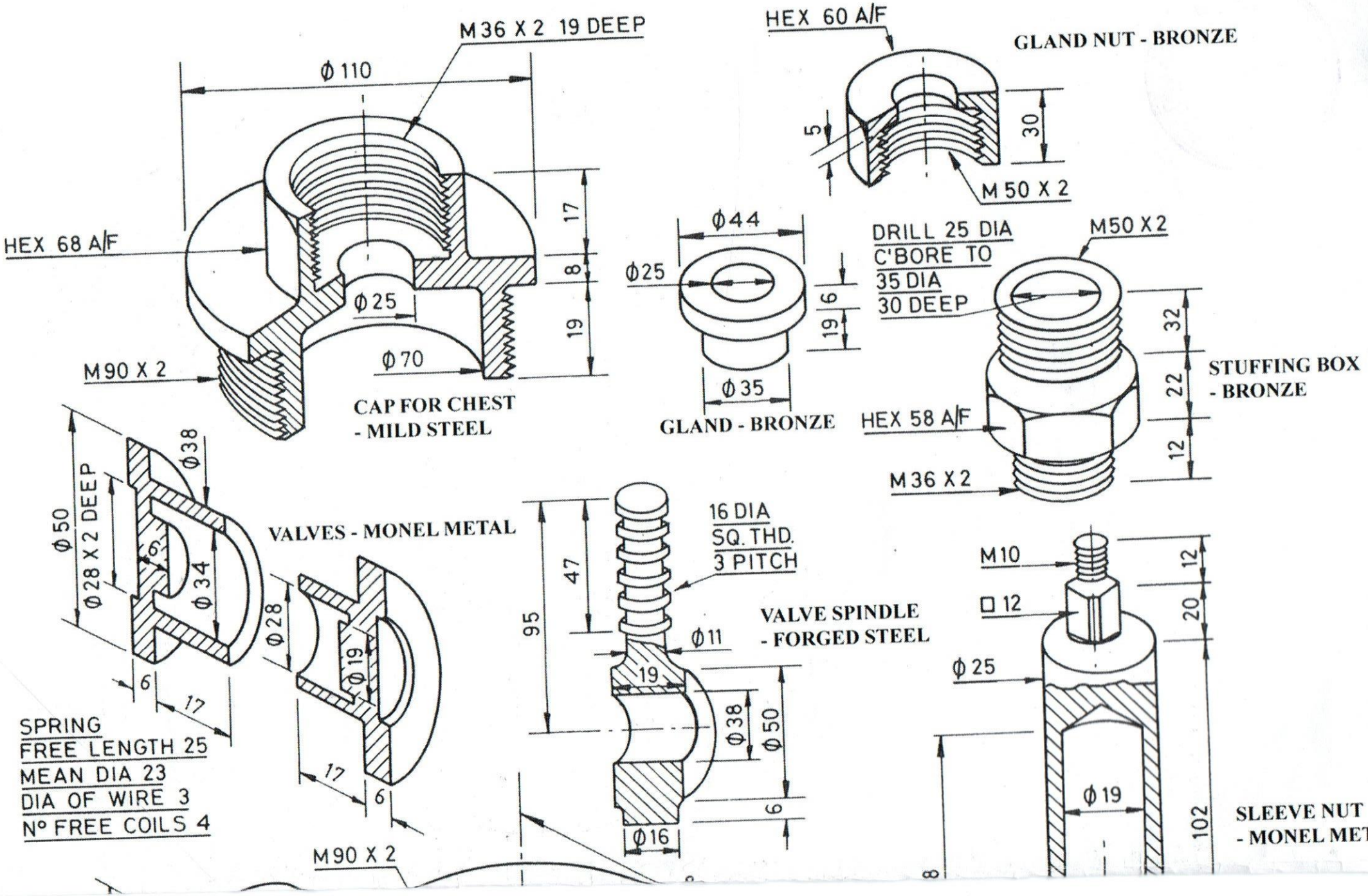
M36 X 2 19 DEEP
Φ110
HEX 68 A/F
Φ25
Φ70
M90 X 2
17
8
19
CAP FOR CHEST
- MILD STEEL
HEX 60 A/F
GLAND NUT - BRONZE
5
30
M50 X 2
Φ44
Φ25
6
19
Φ35
GLAND - BRONZE
DRILL 25 DIA
C'BORE TO
35 DIA
30 DEEP
M50 X2
32
22
12
STUFFING BOX
- BRONZE
HEX 58 A/F
M36 X2
Φ50
Φ28 X 2 DEEP
Φ38
6
Φ34
Φ28
Φ19
6
17
17
6
VALVES - MONEL METAL
SPRING
FREE LENGTH 25
MEAN DIA 23
DIA OF WIRE 3
N° FREE COILS 4
95
47
16 DIA
SQ. THD.
3 PITCH
Φ11
19
Φ38
Φ50
6
Φ16
VALVE SPINDLE
- FORGED STEEL
M90 X 2
M10
□ 12
12
20
Φ25
Φ19
102
8
SLEEVE NUT
- MONEL META

000039

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

MARINE ENGINEERING DRAWING AND DESIGN

- **TIME ALLOWED - FOUR HOURS**
- **Answer All questions**

Date: 2019.06.04 **Pass marks: 50%**

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

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Figure, on the insert, shows details of the component parts of a **Parallel Slide Stop Valve** which can be used on high pressure steam when placed in a pipe line.

Using a suitable scale, draw the following views of fully assembled **Parallel Slide Stop Valve** in **first angle projection**:

(a) Sectional elevation, showing the Valve in the **closed position**. The plane of the section should be through the branches.

(b) End elevation projected to the right of **(a)**

Suitable dimensions should be estimated where not provided. Complete the drawing by including the title, projection symbol, dimensions and a list of materials of parts.

Marking System

(i). Assembling accuracy of view (a)	(45 marks)
(ii). Assembling accuracy of view (b)	(30 marks)
(iii). Optimization of space	(05 marks)
(iv). Six main Dimensioning	(06 marks)
(v). List of materials of parts	(05 marks)
(vi). Title block, projection symbol, lettering	(04 marks)
(vii). Final appearance, neatness	(05 marks

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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

MARINE ENGINEERING DRAWING

- **TIME ALLOWED - FOUR HOURS**
- **Date: 2019.01.11** **Pass marks: 50%**

Instructions to Candidates:

* The Scale used must ensure uniform distribution and coverage of the Drawing sheet.
* Credit will be given for correct spacing of views, neatness and accuracy.
* All construction lines must be clearly shown and do not erase.
* Write your Index Number clearly at the right-hand bottom corner of the drawing paper.

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1. Figure shows the details of a **CONTROL VALVE.**

(a) Draw to a suitable Size in **First Angle** Projection the following views of the assembled CONTROL VALVE.

(i) Longitudinal section through assembled valve with fulcrum pin vertically above right-hand branch looking in the direction 'Z' ***(50 Marks)***

(ii) End elevation looking in the direction 'X' ***(30 Marks)***

(b) Complete the drawing by adding the following:

(i) A part list, with the parts clearly identified on the assembled drawing. ***(04 Marks)***

(ii) A title ***(02 Marks)***

(iii) The projection symbol ***(02 Marks)***

(iv) Six main dimensions ***(06 Marks)***

(v) Correct Spacing ***(02 marks)***

(vi) Sub titles ***(02 marks)***

(vii) Scale ***(02 marks)***

The drawing should be in accordance with B.S.308:1993 and hidden details should be omitted.

Library

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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: 2019.01.10** **Pass marks: 50%**

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

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1. Referring to Risk Management on board ships,
   a. Name the four (04) main steps of risk management process. (04 Marks)
   b. Briefly explain above four (04) steps. (12 Marks)

2. With reference to the Convention of Law of Sea (UNCLOS);
   a. State various sea areas with applicable ranges with an aid of simple sketch. (04 Marks)
   b. Briefly explain the following;
      I. Innocent Passage. (03 Marks)
      II. International Straight. (03 Marks)
      III. Archipelagic State. (03 Marks)
      IV. Exclusive Economic Zone (03 Marks)

3.
   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)

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. Regarding the Marpol Convention;
   a. State the requirements to be fulfilled by a ship for pumping out bilge water accumulated in a machinery space while the ship is in a special sea area as defined by Marpol Annex I. (05 Marks)
   b. What are the categories of hazardous Cargo as per the Marpol Annex II. (02 Marks)
   c. Briefly define two (02) of the categories stated in section "b". (03 Marks)
   d. State the type of sewage systems that could be installed on sea going ships to comply with Marpol Annex IV requirements. (03 Marks)
   e. Briefly State the major amendments effected to Marpol Annex V in 1st March 2018. (03 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 required to be carried on board ships. (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. With reference to SOLAS convention Chapter II-2;
   a. State the fire safety objectives of Chapter II-2. (06 Marks)
   b. Define two main types of bulkheads used in ship construction to fulfill above safety objectives. (06 Marks)
   c. State what is meant by a "Non-Combustible" material. (04 Marks)

8. SOLAS Chapter IX - ISM code introduce to the maritime industry by IMO in 1998.
   a. What is the main purpose of this code. (03 Marks)
   b. What is meant by "Critical equipment" or "Critical Systems" as per the above code. (04 Marks)
   c. Briefly explain the procedures to be followed, stating the documents to be checked, during takeover of duties as an officer In-charge of a watch after Joining a ship. (09 Marks)

9. Maritime Labour Convention 2006 (MLC 2006) by IMO entered in to force 20 Aug 2013.
   a. What was the objective of introducing above convention. (02 Marks)
   b. State the essential documents to be carried on board ship in compliance with MLC 2006 requirements. (05 Marks)
   c. What are the Rest & Work hours requirement according to MLC 2006. (04 Marks)
   d. State 05 areas subjected to inspect on board ship during MLC inspection by the inspectors. (05 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

THERMODYNAMICS

- **TIME ALLOWED - THREE HOURS**
- **Answer SIX questions only**
- **Date: 2019.01.09** **Pass marks: 50%**

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

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

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***

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1. Steam initially at ***155.5°C*** and ***1 bar***, is compressed reversibly and isothermally to a state where the specific volume is ***0.28 m^3/kg***. Find:

   a. The condition of the steam in the final condition (4 marks)

   b. The change of internal energy (4 marks)

   c. The change of entropy (4 marks)

   d. The heat transferred (4 marks)

   e. The Work done/kg of steam (4 marks)

2. A gas at a pressure of **1680 kPa** and temperature of **350°C** is expanded adiabatically to a pressure of **120 kPa**. The gas is then heated at constant volume until the temperature reaches **350°C**, when its pressure is found to be **264 kPa**. Finally, the gas is compressed isothermally until the original pressure of **1680 kPa** is obtained.

   a. Sketch the $p-V$ and $T-s$ diagrams for this process. (4 marks)

   b. If the gas has a mass of **0.23 kg**, find:

      i. The value of adiabatic index. (10 marks)

      ii. The change in internal energy during adiabatic expansion. (6 marks)

   Take C_p= 1.005 kJ/kgK.

3. An engine working on an ideal ***Diesel cycle*** has a clearance volume of ***0.00025 m^3***. It has a bore and stroke of ***152.5 mm*** and ***200 mm***, respectively. At the beginning of adiabatic compression the air in the cylinder has a pressure of ***100 kPa*** and temperature of ***20 ^0C***, respectively. The maximum temperature of the cycle is ***1090 ^0C***. Determine

   a. The temperature and pressure at the end of the adiabatic compression (7 marks)

   b. The temperature and pressure at the end of the adiabatic expansion (4 marks)

   c. The thermal efficiency of the cycle (4 marks)

   d. The fraction of the stroke at which combustion is theoretically complete (5 marks)

4.

   a. Write an expression for the air standard efficiency of a dual cycle with usual notations. (2 marks)

   b. A dual combustion cycle has a compression ratio of ***15*** and compression begins at ***0.1 MPa*** and ***40^0C***. The maximum pressure is limited to ***6 MPa*** and the heat added is ***1.675 MJ/kg***. Compute:

      i. The heat supplied at constant volume per kg of air (3 marks)

      ii. The heat supplied at constant pressure per kg of air (3 marks)

      iii. The work done per kg of air (3 marks)

      iv. The cycle efficiency (3 marks)

      v. The cut-off ratio (3 marks)

      vi. The mean Effective Pressure of cycle (3 marks)

5. A single stage – single acting air compressor has a bore of ***200 mm*** and stroke of ***300 mm***. It runs at ***420 rpm*** and the clearance to swept volume ratio is ***0.065***. The index of compression can be assumed as ***1.3.*** The intake pressure is ***100 kPa*** and intake temperature is ***27^0C***. Delivery pressure is ***500 kPa***. Determine:

   a. Free Air Delivery at NTP in m^3/hr (4 marks)

   b. Delivery air temperature (4 marks)

   c. Volumetric efficeincy (4 marks)

   d. Power required (4 marks)

   e. Isothermal efficiency (4 marks)

   (Hint: *NTP - Normal Temperature and Pressure - air at 20°C and 1.01325 bar)*

6. The analysis of a sample of coal burned in the furnace of a boiler is ***85%*** of ***Carbon***, ***5% Hydrogen***, ***4% Oxygen***, and the remainder ***ash***. Calorific values of C and H are ***33MJ/kg*** and ***144 MJ/kg*** respectively. Determine

   a. The ***calorific value*** of the fuel (4 marks)
   b. The ***theoretical mass of air required per kg of coal*** for perfect combustion taking the molecular mass of ***C, H*** and ***O 12, 1*** and ***16*** respectively (4 marks)
   c. The ***actual mass of air*** if it is supplied with ***75% excess*** (4 marks)
   d. The ***percentage mass analysis of the products*** of combustion (8 marks)

7. A steam power plant which operates on an ideal Rankine cycle and has a net power output of ***42 MW***. Steam enters the turbine at ***7 MPa*** and ***500 ^{0}C*** and is cooled in the condenser at a pressure of ***10 kPa*** by running cooling water from a lake through the tubes of the condenser at a rate of ***600 kg/s***.

   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 temperature rise of the cooling water (4 marks)

8. A test of Marine slow speed ***2-stroke*** Diesel Engine with six-cylinder resulted the following data at the engine load ***75%*** of maximum continuous rating (MCR): indicated power ***6580 kW***. The engine has a bore of ***500 mm*** and stroke of ***1910 mm*** and the mechanical efficiency is ***93 %***. At a speed of ***110 rev/min***, The engine uses ***1050 kg*** of fuel per hour and lower calorific value of Marine Diesel fuel is ***42.625 MJ/kg***.

   Estimate

   a. The indicated power, brake power and friction power per cylinder (6 marks)
   b. The indicated mean effective pressure and brake 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. 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***,

   a. Determine
      i. The ***dryness fraction*** at inlet to the evaporator (3 marks)
      ii. ***Refrigerant effect per minute*** (3 marks)
   b. Show that the refrigerant will be ***completely dried*** at the end of compression (4 marks)
   c. Draw the ***TS diagram*** for the cycle (4 marks)
   d. Determine the compressor ***work done per minute*** and ***coefficient of performance*** of the plant (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

MATHEMATICS

- **TIME ALLOWED - THREE HOURS**
- **Answer SIX questions only**
- **Date: 2019.01.08** **Pass marks: 50%**

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

1.

a. Determine the partial fractions of $\frac{x}{(x+1)(x^2+1)}$ (5 marks)

b. If $a=\log\frac{10}{9}, b=\log\frac{25}{24}$ and $c=\log\frac{81}{80}$, show that $7a-2b+3c=\log 2$ (5 marks)

c. Show that is $x-2$ a factor of x^3+3x^2-6x-8 and hence find the other factors of the expression (5 marks)

d. Solve the inequality $\frac{2}{x-1}\geq 2-x$ (5 marks)

2. A quadratic function is defined by $f(x)\equiv x^2+3x+9$.

a. Find the set of values of k for which $f(x)=kx$ has no real roots. (8 marks)

b. By considering the identity $x^2+3x+9=(x+A)^2+B$, where A and B are constants, find the greatest value of $\frac{1}{f(x)}$. (6 marks)

c. Sketch the curve $y=f(x)$, showing any intercept with the coordinate axes. (6 marks)

3.

a. Plot following complex numbers in argand diagram

i. $\frac{2-i}{1-i}$ (4 marks)

ii. $\frac{(1+i)^2}{(1-i)}$ (4 marks)

b. Convert following complex numbers to rectangular form

i. $2\angle -45^0$ (3 marks)

ii. $3\angle 30^0$ (3 marks)

c. Simplify $\left\{\left(2\angle\left(\frac{\pi}{6}\right)\right)^2\left(3\angle\left(\frac{\pi}{4}\right)\right)\right\}\Big/\left(4\angle\left(\frac{\pi}{3}\right)\right)^3\Big\}$ (6 marks)

Hint: $r\angle\theta \equiv r(Cos\,\theta + i\,Sin\,\theta)$

4. For two given matrices $A = \begin{bmatrix} 1 & -1 & 1 \\ 1 & 2 & 2 \\ 1 & 1 & 2 \end{bmatrix}$ and $B = \begin{bmatrix} 1 & 4 & 5 \\ 2 & 6 & 8 \\ 3 & 7 & 22 \end{bmatrix}$

a. Find AB^T and BA^T (8 marks)

b. Find the adjoint of A (8 marks)

c. Hence find the inverse of A (4 marks)

5.

a. Prove that

i. $\dfrac{2Cos\,x}{Cot\,x\,Cos\,x - Sin\,x} = Tan\,2x$ (3 marks)

ii. $Sin4\theta\,Cos\theta - Cos2\theta\,Sin\theta = Sin3\theta\,Cos2\theta$ (3 marks)

b. Prove that $\dfrac{Sin(A-B)}{CosA\,CosB} = \tan A - \tan B$ Hence show that

$$\frac{Sin(A-B)}{CosA\,CosB} + \frac{Sin(B-C)}{CosB\,CosC} + \frac{Sin(C-A)}{CosC\,CosA} = 0$$ (6 marks)

c. Given that $\tan\dfrac{\theta}{2} = t$, express $3Cos\theta + 2Sin\theta$ in terms of t. Hence solve the equation $3Cos\theta + 2Sin\theta = 3$ (8 marks)

6.

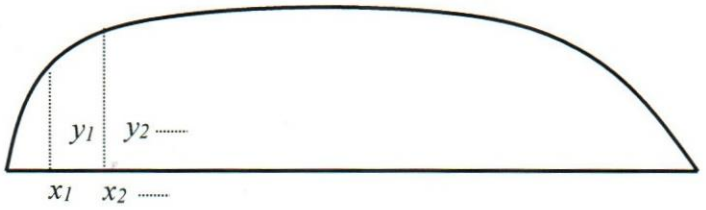
a. Differentiate the following functions with respect to x

i. $y = x^2 \ln|\sin x|$ (5 marks)

ii. $y^2 + 2xy - x^2 + 3x = 0$ (5 marks)

b. The distance s travelled by a body propelled vertically upward in time t is given approximately by the formula $s = 120t - 4.9t^2$. Find the greatest height which the body will reach and the time taken (10 marks)

7. Figure shows the variation of height of a lamina along the x- axis from 0 to 10m



x (m)	0	1	2	3	4	5	6	7	8	9	10
y (m)	0	3.75	4.95	5	5	5	5	4.75	3.5	2.4	0

a. Determine the area of the lamina in the figure by using the coordinates given in the table. (Hint: Simpson's 1/3 rule). (6 marks)

b. Find the center of gravity of the lamina about x-axis. (8 marks)

c. Hence, determine the volume generated by half of a revolution (π radians) of the lamina in the figure about x-axis. (Hint: Pappas theorem) (6 marks)

8.

a. Evaluate

(i) $\int\left(x-\frac{1}{x}\right)^2 dx$ (ii) $\int\frac{(x+1)^2}{x^3}dx$ (iii) $\int\frac{2x}{(x-2)(x-3)}dx$ (9 marks)

b. Find the area of the region R bounded by $y = x^3$, $x = 0$, $x = 2$. (5 marks)

c. If R is rotated around x axis by a complete revolution, find the volume of the solid generated. (6 marks)

9.

a. Find vertical and horizontal asymptotes of $f(x)=\frac{x^2-1}{x^2-4}$ (5 marks)

b. Find and classify all stationary points of $f(x)$ (8 marks)

c. Sketch the curve of the function $y = f(x)$. (7 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 Four (04) Questions from* ***Part A*** *and Two (02) Questions from* ***Part B***
- **Date: 2019.01.07** **Pass Mark 50%**

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

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Part A

1) a) i. Explain self-induced EMF. (3 marks)

ii. Express the equation of self-inductance for the inductor. (3 marks)

b) A long solenoid has 400 turns wound on a cylinder of magnetic material with $\mu_r = 1700$, with radius 0.80 cm and length 7.0 cm. (8 marks)

i. Calculate the inductance of the coil.

ii. If the current in the coil increases at the rate of 0.753 As^{-1} find the induced voltage.

c) When two coils are connected in series, their effective inductance is found to be 10 H. When the connections of one coil are reversed, the effective inductance is 6 H. If the coefficient of coupling $k = 0.6$ and mutual inductance given by $M = k\sqrt{L_1 L_2}$, calculate the self-inductance of each of coil and the mutual inductance. (6 marks)

2) a) Explain power factor in a.c. power systems. (5 marks)

b) A 230 V, 50 Hz a.c. supply is applied to a coil of 0.06 H inductance and 2.5 Ω resistance connected in series with a 6.8 μF capacitor. Calculate (8 marks)

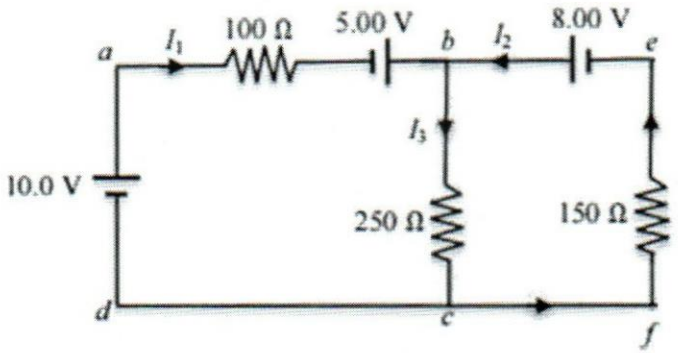
i. impedance.

ii. power consumption and power factor.

c) In above a.c. circuit, A inductor of 0.2H is connected in parallel with the power supply, find new power factor and power consumption. (7 marks)

3) a) Express Kirchhoff current and voltage laws. (6 marks)

b) Consider the DC circuit shown in Figure 1 and note that the direction of the currents shown in the figure are arbitrary. (14 marks)



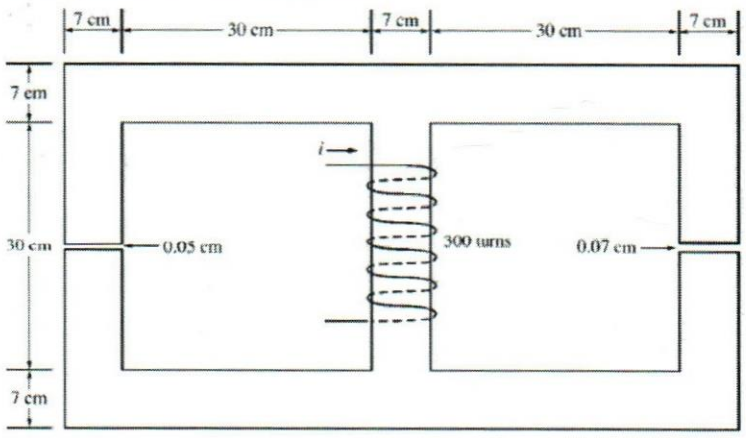
i. Find each branch current.

ii. What is the direction of the current through 250 Ω resistor? (from b to c or from c to b)

iii. Determine the potential difference Ve – Vf, with the appropriate sign.

4) a) Explain the term 'Permeability' with the aid of B-H curve (5 marks)

b) Refer the following magnetic circuit made of iron (relative permeability = 4000) with two airgaps in each branch of the circuit. All dimensions are in centimeters and the magnetic material has a square cross-sectional area.



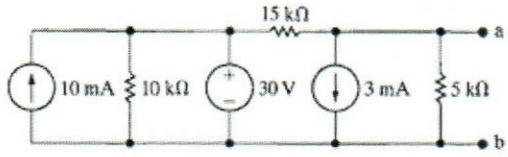
When 250A current flows through the coil, calculate;

i. Magnetic flux through each air gap. (12 marks)

ii. Equivalent reluctance of the circuit. (3 marks)

5) a) Explain the 'Norton's theorem' with the aid of appropriate diagrams. (6 marks)

b) Refer the following network



i. Simplify the above circuit using Norton's theorem (8 marks)

ii. Calculate the voltage across ab when no load is connected in between (2 marks)

iii. What should be the resistance connected across ab to observe a power consumption of 2.5kW (4 marks)

6) A DC shunt generator delivers an output current of 195A at terminal voltage of 250V. Armature resistance and field resistance are 0.02Ω and 50Ω respectively.

a) Draw the equivalent circuit of the generator and mark the given information correctly on the circuit. (6 marks)

b) Calculate

i. Output power delivered (3 marks)

ii. EMF generated. (3 marks)

iii. Input mechanical power (2 marks)

iv. Overall efficiency of the generator (2 marks)

c) It was observed that the terminal voltage is dropped to 4.5V after connecting a variable resistor of 100Ω in series with the field winding and is suddenly increased again to 230V when the resistance of variable resistor is gradually reduced. Explain this phenomena with the aid of appropriate diagrams (4 marks)

Part B

7) a) Explain with an aid of a diagram how Electrical Transformers work. (5 marks)

b) Explain the losses which are encountered in transformers. (5 marks)

c) Briefly explain the types of Transformers used in shipboard electrical practice. (5 marks)

d) Briefly explain with an aid of a diagram how 3 phase transformer can be connected to primary and secondary side busbars. (5 marks)

8) a) With regards to Induction Motors, explain how Rotor torque is developed. (10 marks)

b) With reference to protection of electrical equipment's:

i. State purpose of protective devices. (5 marks)

ii. list the protective devices fitted in A.C. motor starters. (5 marks)

9) With reference to the A.C. generator

a) What are the main types of generators? (4 marks)

b) Which type is most suitable for slow speed prime movers? (4 marks)

c) State the principle requirements for synchronizing A.C. generators. (3 marks)

d) How could you monitor the correct instant for synchronizing? (3 marks)

e) What are the likely consequences may occur when these generators are incorrectly synchronized? (3 marks)

f) How is active power(kW) and reactive power(kVAR) sharing achieved? (3 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: 2019.01.03 Pass marks: 50%

Part A: NAVAL ARCHITECTURE

1. The half ordinates at the summer draft of a 120m long ship are as follows.

Section	AP	1	2	3	4	5	6	7	8	9	FP
½ Ordinates(m)	2.5	3.6	5.6	7.0	8.0	8.3	7.6	6.2	5.2	2.4	0

   a. Calculate the area of the water plan at summer draft of the ship. (08 marks)

   b. Find the longitudinal center of floatation (LCF) at this draft. (08 marks)

2. A ship of 10,000 tonne displacement has its center of gravity 6.0 m above the keel (KG). The vessel was modified to install with 150 tonne Ballast Water Treatment plant having 5.5 m center of gravity above the keel. During modification 50 tonne section of a deck structure having 4.5 m center of gravity above keel was removed from the vessel.

   a. Calculate the vessel's new vertical center of gravity (kg) after the modification. (08 marks)

   Before proceeding for loading port the vessel loaded with 800 tonne of fuel into DB tanks having center of gravity 0.7 m above the keel and 100 tonne of fresh water into F.W. tank having center of gravity 5.2 m above the keel.

   b. Calculate the vertical center of gravity (kg) of the vessel when arriving at a port, consuming 460 tonne of fuel in DB tanks and 50 tonne of fresh water in F.W. tank during her passage.

   (08 marks)

3.

a. List down the conditions to be observed before and while performing the inclining experiment. (06 marks)

b. A ship of 2304 tonnes displacement has an initial metacentric height of 1.2 m. Find the deflection in a plumb line which is suspended from a point 7.2 m above a batten when a mass of 15 tonnes, already on board, is shifted 10 m transversely across the deck. (10 marks)

4. A ship 120 m long has a light displacement of 1500 tonnes and LCG 3.24 m aft of mid-ship.

The following items are now loaded:

Cargo 3500 tonne, LCG 5.20 m forward of mid-ship
Fuel 200 tonne, LCG 36.00 m aft of mid-ship
Water 30 tonne, 36.25 m aft of mid-ship
Stores 5 tonne, 38.00 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	5235	26.00	1.25 F	2.34 A

Calculate the final end drafts of the vessel. (16 Marks)

5. Resistance exerted by the water on a ship when moves through the water at a speed could be divided into two main components as Frictional Resistance & Residuary Resistance.

a. List the factors effecting the magnitude of each of above component. (06 marks)

b. A 6.0 m mild steel model of a ship has a wetted surface area of 10.0 m^2 and when towed in Sea water at 03 knots, has a total resistance of 58 N. If the "Ship correlation Factor" (SCF) is 1.15, Calculate the effective power of a ship, 120 m long, at its corresponding speed. (10 marks)

$f = 0.417 + \frac{0.773}{L+2.862}$ and $R_f = f S V^n$, n = 1.825 when V in Knots

6.

a) Define following terms with respect to marine propellers;

i. Pitch Ratio (02 marks)

ii. Theoretical Speed (02 marks)

iii. Apparent Slip (02 marks)

iv. Real Slip (02 marks)

b) A propeller of 6.0 m diameter has a pitch ratio of 0.8. When main engine turns at MCR propeller rotates at 120 RPM. The wake fraction is found to be 0.28 & the real slip 32 %.

Calculate;

i. Speed of advance (04 marks)

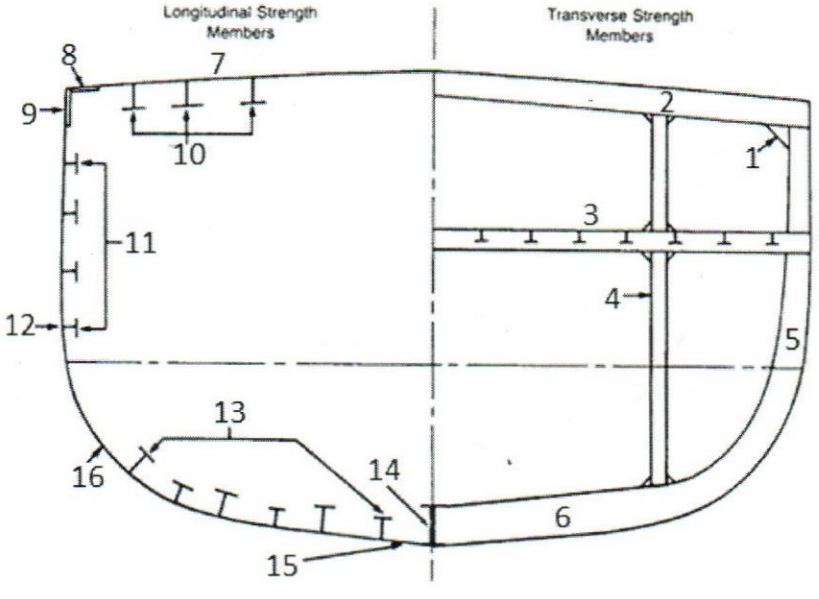
ii. The speed of the ship (02 marks)

iii. Apparent slip (02 marks)

PART B: SHIP CONSTRUCTION

7. List the **location**, **functions** and the **benefits** of following
   a. Bilge wells engine room and cargo holds (04 marks)
   b. Tank Vents (03 marks)
   c. Bell Mouths at Tank Suction end (03 marks)
   d. Sounding pipe Striker Plates (03 marks)
   e. Deck Scuppers (03 marks)

8.
   a. Identify the components marked 1 to 16 on the Fig. 01 below and briefly state their function. (10 marks)
   b. State and draw type of weld symbols illustrating butt, fillet and corner joints used in ship construction process. (03 marks)
   c. Define Class A and Class B bulkheads used for ship construction and state their sub categories according to the standard fire test. (03 marks)



9. Considering the design of the fore end structure with respect to local loads stresses, stability, safety and ship resistance;
   a. With the aid of a simple sketch, explain how a ship is structurally strengthened to counter the effects of slamming and panting. (06 marks)
   b. Explain in general terms the routine maintenance of hatch covers and test being carried out to verify the weather tightness. (04 marks)
   c. Briefly state the function of the bulbous bow and explain how these functions are effected. (06 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

MARITIME LAW

- **Time Allowed - Three Hours**
- *Answer Any **SIX (06)** Questions.*

- **Date: 2018.09.04** **Pass Mark 50%**

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

1. Referring to Risk Management on board ships, briefly define following terms;
   a. Hazards (03 Marks)
   b. Risk. (03 Marks)
   c. Risk Assessment. (03 Marks)
   d. Control Measures (03 Marks)
   e. List 02 numbers of hazard that could involve with Purifier overhaul and briefly explain the control methods could be used to mitigate the risk from those hazards. (04 Marks)

2. With reference to the Convention of "Law of the Sea", Explain the followings
   a. Innocent passage (03 Marks)
   b. Exclusive Economic Zone (03 Marks)
   c. Transit Passage (03 Marks)
   d. Briefly explain the Rights and Responsibilities of authorities at each sea areas. (07 Marks)

3. International Maritime Organization (IMO) was established in 1948.
   a. What are the primary responsibilities of IMO. (03 Marks)
   b. State the five (05) main committees of IMO. (05 Marks)
   c. What are the five (05) instruments that IMO uses to adopt the various legislations. (05 Marks)
   d. What is mean by "Ratification" of a Convention by a Member state. (03 Marks)

4. Survey & Certification is one of the important process of a merchant ships.
   a. Briefly explain why it is required to carry out surveys and issue a certificate for sea going vessels. (02 Marks)
   b. State five (05) parties interested in ship certification. (05 Marks)
   c. Name the main categories of ship certificates. (03 Marks)
   d. State the advantages of Harmonized Survey & Certification system. (02 Marks)
   e. State the main areas covered by the certificate issued to a ship by classification society. (04 Marks)

5.

a. What are the important amendments made to the STCW convention at Manila in 2010 (04 marks)
b. What are the objectives of the ISM Code (04 Marks)
c. Define followings with reference to ISM,
   i. Observation (04 Marks)
   ii. Non conformity (04 Marks)

6. As per Marpol convention

a. State the provision in Marpol Annex I with regard to discharge of oily bilge mixtures from ships while in special area and outside of special area. (04 Marks)
b. List down the entries to be made in oil record book part I and part II. (04 Marks)
c. What are the requirements to be fulfilled before discharging sewage in to the sea from seagoing vessel? (04 Marks)
d. State the principle amendments made to Marpol Annex-V in March 2018 (04 Marks)

7.

a. State the main objectives of assigning Free Board for a ship. (04 Marks)
b. What is meant by "Free Board" & "Reserve Buoyancy" of a ship? (06 Marks)
c. List 06 different types of items comes under Record of Conditions of Assignment for assigning Load Line for a ship. (06 Marks)

8. International Ballast Water Management convention was adopted by IMO & is in force since 2017/Sept.

a. State the reasons urged for IMO to introduce this convention. (02 Marks)
b. What are the ships that require to comply with regulations of the convention during seawater ballast operation? (01 Marks)
c. What are the ships that may be exempted from the requirements of this convention? (03 Marks)
d. What are the documents to be carried on board ships to comply with the requirement of this convention? (04 Marks)
e. What are the two standards for Ballast Water Management as per the BWM Convention. (06 Marks)

9.

a. Briefly explain the main factors urged for IMO to introduce Maritime Labour Convention (MLC 2006). (02 Marks)
b. State five (05) important documents required to be on board ship under this convention. (05 Marks)
c. There are fourteen (14) mandatory areas which subject to inspection by MLC inspectors on board ship. State nine (09) of these areas. (09 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 Any **SIX (06)** Questions.*
- **Date: 2018.08.31** **Pass Mark 50%**

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

1. a. For two given matrices If $A = \begin{bmatrix} 1 & -2 & 3 \\ 2 & 3 & -1 \\ -3 & 1 & 2 \end{bmatrix}$ and $B = \begin{bmatrix} 1 & 0 & 2 \\ 0 & 1 & 2 \\ 1 & 2 & 0 \end{bmatrix}$

   Find AB and BA (8 marks)

   b. Find the adjoint of A. (8 marks)

   c. Hence find the inverse of A (4 marks)

2. a. Prove that

   i. $Cos2\theta = 2Cos^2\theta - 1 = 1 - 2Sin^2\theta$

   ii. $Sin\ 3\theta = 3Sin\theta - 4Sin^3\theta$ (6 marks)

   b. Hence or otherwise find the solutions of the equation

   $4Sin^3\theta - 2Sin^2\theta - 3Sin\theta + 1 = 0$ between 0 and 2π radians. (6 marks)

   c. Two chimneys AB and CD are of equal lengths. A person standing between them in line AC joining there bases observes the elevation of the one near to him to be 45^0. After walking 80 ft. in the direction at right angle to AC he observes their elevation to be $60^0$and 30^0. Find their height and distance apart. (8 marks)

3. a. Evaluate i) $\int xsindx$ ii) $\int 5log_e xdx$ iii) $\int 2xe^{2x}dx$ (9 marks)

   b. Find the area of the region R bounded by $y = x^2$, $x = -1$ and $x = -3$. (5 marks)

   c. If R is rotated around x axis find the volume of the solid generated. (6 marks)

4. a. Suppose $y = x^2 - xy$

i. Find the slope of the line tangent to the curve where x = 1.

ii. Find the equation of the line tangent to the curve where x = 1. (6 marks)

b. If $z = \frac{x}{x^2-y^2}$ find all the first order and second order partial derivatives. (8 marks)

c. A rectangular sheet of metal with length 6 meters and width 2 meters is given. Four equal squares are removed from the corners. The sides of this sheet are now turned up to form an open rectangular box. Calculate approximately the height of the box, such that the volume of the box is maximum. (6 marks)

5.

a. Show that $\log_2 12 = 2 + 3\log_8 3$ (5 marks)

b. If $2^x = 3^y = 6^z$, show that $xy = z(x+y)$ (5 marks)

c. Solve the simultaneous equation

$$3^x - 2^{y+2} = 4$$
$$3^{x-1} + 2^{y+1} = 3$$ (5 marks)

d. Determine the partial fractions of $\frac{x^2+2x+1}{(x-2)(2x^2+x-3)}$ (5 marks)

6. A quadratic function is defined by

$$f(x) = x^2 + (k+1)x + 4$$

where k is a constant. It is given that the equation f(x) =0 has two distinct real roots.

a. Find the set of values that k can take. (6 marks)

b. For the case where $k = -5$,

i. express $f(x)$ in the form $(x-a)^2 + b$, stating the values of a and b, and hence write down the least value taken by $f(x)$, (6 marks)

ii. Solve the equation $f(x) = 0$, expressing your answer in terms of surds, simplified as far as possible. (4 marks)

iii. Sketch the quadratic function *f(x)* (4 marks)

7.

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

i. $2z_1 - z_2 + 3z_3$

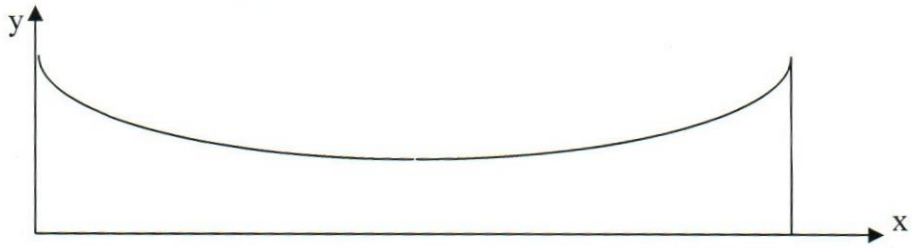
ii. $z_1 \times (z_2 - 2z_3)$

iii. $\dfrac{iz_1 + z_3}{z_2}$ (12 marks)

Hint: $r\angle\theta \equiv r(Cos\theta + i\,Sin\theta)$

b. Find the square root of $3 - i$ (8 marks)

8. Figure represents a lamina made by coordinates given in the table below. Use the table and figure for the followings



x(m)	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0
y(m)	1	0.85	0.75	0.7	0.65	0.62	0.6	0.58	0.55	0.58	0.6	0.62	0.65	0.7	0.75	0.85	1

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)

9. For the function, $f(x) = 2x^4 - 4x^2$

a. Find all the real roots of the function, *f(x)* (4 marks)

b. Find all the stationary values of the function, *f(x)* and the nature of them (6 marks)

c. Hence, plot the function for all real values of x (6 marks)

d. Estimate the area under the function in the domain of $-\sqrt{2} \le x \le \sqrt{2}$ (4 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

NAVAL ARC & SHIP CONSTRUCTION

- **Time Allowed - Three Hours**
- **Attempt only (06) Questions**
- *Answer Four (04) Questions from* ***Part A****, and Two (02) Questions from* ***Part B.***

- **Date: 2018.08.28** **Pass Mark 50%**

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

Part A

1. The half ordinates of a water plane 100m long are as follow.

Section	AP	0.5	1	1.5	2	3	4	5	6	7	8	8.5	9	9.5	FP
Half ordinates	1.2	3.5	5.3	6.8	8.0	8.3	8.5	8.5	8.5	8.4	8.2	7.9	6.2	3.5	0 m

Calculate:

a. Water plane area (10 marks)
b. Distance of centroid from mid ship (10 marks)

2.

a. Explain free surface effect. (10 marks)
b. A ship of 6000T displacement has it's center of gravity 5.9m above the keel and transverse metacenter 6.8m above the keel. A rectangular double bottom tank 105m long, 12m wide, and 1.2m deep is now half filled with sea water.
Calculate the metacentric height. (10 marks)

3.

a. What is the purpose of doing inclining experiment? (8 marks)

b. A ship of 3000T displacement floating at a draught of 4.2m has the following particulars, KB = 2.3m, KG = 6.5m, BM = 5.6m and TPC = 10.
Determine the angle of heel when a mass of 200T, KG= 9.5m is added to the vessel at a position 2.5m off centreline. Assume that the vessel is "wall sided" over the effective range of draught. (12 marks)

4.

A ship of 5000T displacement, 96m long, floats at a draughts of 5.6m forward and 6.3m aft. The TPC is 11.5, GM_L 105m and centre of floatation 2.4m aft of midships.

Calculate:

a. The MCT 1cm (10 marks)
b. The new end draughts when 88T are added 31m forward of midships. (10 marks)

5.

a. Define following

i. Stable equilibrium (04 marks)

ii. Unstable equilibrium (04 marks)

iii. Neutral equilibrium (04 marks)

b. A load of 34MT shifted 12m vertically upward and then 8m transversely to port side. If the vessel was initially upright and having initial KG, KM and a displacement of 7.7m, 8.5m, and 15500T respectively. Find the new GM and angle of list. (08 marks)

6. A ship's displacement is 4500tonnes and KG 5m. The following cargo is loaded:

450 tonnes KG 7.5 m

120 tonnes KG 6.0 m

650 tonnes KG 3.0 m

Find the amount of cargo to load in a tween deck (KG 6m) so that the ship sails with a GM of 0.6 m. (The load KM is 5.6 m.) (20 marks)

Part B

7.

a. Sketch the midship section of a ship, labelling EACH of the following and state the advantage of introducing them in ship construction

i. Camber (03 marks)

ii. Bilge radius (03 marks)

iii. Bilge keel (03 marks)

iv. Flat of bottom (03 marks)

v. Rise of floor (03 marks)

b. State **FIVE** terms used to describe the conditions that relate to the distortion of a hull undergoes, stating in **EACH** case, the **stresses** involved. (05 marks)

8. a. With reference to stiffeners used in ship construction

   i. Distinguish clearly the type of steel sections with respective designations. (02 marks)

   ii. State the use of longitudinal stiffeners, hatch side girders, deck longitudinal, hatch side girders etc in a longitudinally framing system. Show and identify the contribution of transverse members in stiffening the same. (04 marks)

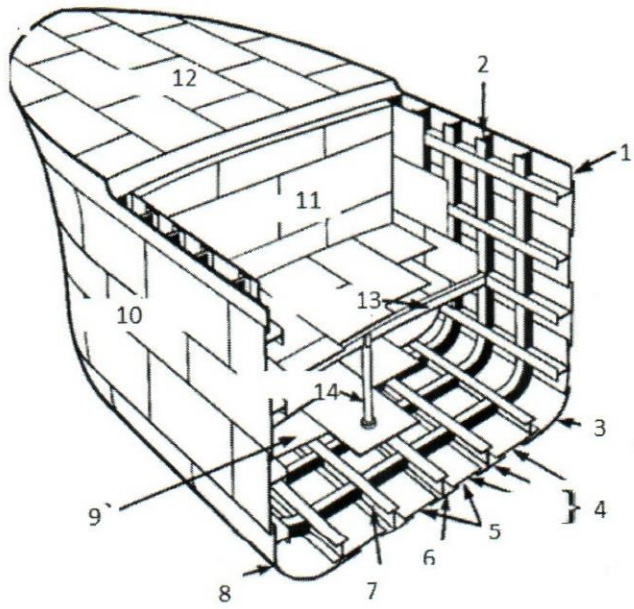
   iii. Construct a flanged or un-flanged bracket joining the main deck and side shell. State the necessity of scallops cut on a bracket (04 marks)

   iv. With reference to bottom construction of a ship, explain with clear labeled sketches the joining of floor plate with longitudinal and transverse beam at cutouts for watertight and non -watertight floor arrangements respectively. (04 marks)

   b. i. Show construction details of a transverse section of a bulk career showing all members of the construction. (04 marks)

   ii. Stringers or/and longitudinal frames are not used for above construction. Why? (02 marks)

9. a. Identify the components from 1 to 14 marked on the sketch and explain their construction (06 marks)



   b. List and briefly describe the main drawings and plans available on board ship. (06 marks)

   c. Enumerate the examinations and tests which should be carried out on the exterior of a ship's hull when in duty dock. Detail the inspection necessary in the region of the ship's hull, which is adjacent to the machinery spaces. Discuss the nature of defects liable to be found in these areas. (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

MARITIME LAW

- **Time Allowed - Three Hours**
- *Answer Any **SIX (06)** Questions.*
- **Date: 2018.09.04**

Pass Mark 50%

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

1. Referring to Risk Management on board ships, briefly define following terms;
   a. Hazards (03 Marks)
   b. Risk. (03 Marks)
   c. Risk Assessment. (03 Marks)
   d. Control Measures (03 Marks)
   e. List 02 numbers of hazard that could involve with Purifier overhaul and briefly explain the control methods could be used to mitigate the risk from those hazards. (04 Marks)

2. With reference to the Convention of "Law of the Sea", Explain the followings
   a. Innocent passage (03 Marks)
   b. Exclusive Economic Zone (03 Marks)
   c. Transit Passage (03 Marks)
   d. Briefly explain the Rights and Responsibilities of authorities at each sea areas. (07 Marks)

3. International Maritime Organization (IMO) was established in 1948.
   a. What are the primary responsibilities of IMO. (03 Marks)
   b. State the five (05) main committees of IMO. (05 Marks)
   c. What are the five (05) instruments that IMO uses to adopt the various legislations. (05 Marks)
   d. What is mean by "Ratification" of a Convention by a Member state. (03 Marks)

4. Survey & Certification is one of the important process of a merchant ships.
   a. Briefly explain why it is required to carry out surveys and issue a certificate for sea going vessels. (02 Marks)
   b. State five (05) parties interested in ship certification. (05 Marks)
   c. Name the main categories of ship certificates. (03 Marks)
   d. State the advantages of Harmonized Survey & Certification system. (02 Marks)
   e. State the main areas covered by the certificate issued to a ship by classification society. (04 Marks)

5.

a. What are the important amendments made to the STCW convention at Manila in 2010 (04 marks)
b. What are the objectives of the ISM Code (04 Marks)
c. Define followings with reference to ISM,
   i. Observation (04 Marks)
   ii. Non conformity (04 Marks)

6. As per Marpol convention

a. State the provision in Marpol Annex I with regard to discharge of oily bilge mixtures from ships while in special area and outside of special area. (04 Marks)
b. List down the entries to be made in oil record book part I and part II. (04 Marks)
c. What are the requirements to be fulfilled before discharging sewage in to the sea from seagoing vessel? (04 Marks)
d. State the principle amendments made to Marpol Annex-V in March 2018 (04 Marks)

7.

a. State the main objectives of assigning Free Board for a ship. (04 Marks)
b. What is meant by "Free Board" & "Reserve Buoyancy" of a ship? (06 Marks)
c. List 06 different types of items comes under Record of Conditions of Assignment for assigning Load Line for a ship. (06 Marks)

8. International Ballast Water Management convention was adopted by IMO & is in force since 2017/Sept.

a. State the reasons urged for IMO to introduce this convention. (02 Marks)
b. What are the ships that require to comply with regulations of the convention during seawater ballast operation? (01 Marks)
c. What are the ships that may be exempted from the requirements of this convention? (03 Marks)
d. What are the documents to be carried on board ships to comply with the requirement of this convention? (04 Marks)
e. What are the two standards for Ballast Water Management as per the BWM Convention. (06 Marks)

9.

a. Briefly explain the main factors urged for IMO to introduce Maritime Labour Convention (MLC 2006). (02 Marks)
b. State five (05) important documents required to be on board ship under this convention. (05 Marks)
c. There are fourteen (14) mandatory areas which subject to inspection by MLC inspectors on board ship. State nine (09) of these areas. (09 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

ENGINEERING DRAWING

- **Time Allowed - Four Hours**
- **Date: 2018.09.05** **Pass Mark 50%**

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

NB: *(1)* ***The Scale used must ensure uniform distribution and coverage of the Drawing sheet.***

(2) ***Neatness in Drawing carries weightage***

Q1. Figure shows details of a **Crane Hook**.

(a) Draw

(i) Sectional Elevation through the axis of the Swivel block showing all parts assembled. *(50 marks)*

(ii) End Elevation *(30 marks)*

(b) Complete the drawing by adding the following,

(i) A parts list, with the parts clearly identified on the assembled drawing *(06 marks)*

(ii) A title *(02 marks)*

(iii) The projection symbol *(02 marks)*

(iv) Six main dimensions *(06 marks)*

(v) Neatness *(02 marks)*

(vi) Scale and Spacing *(02 marks)*

The drawing should be in accordance with B.S.308:1993 and hidden detail should be omitted.

E/① Class - III

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 Any **SIX(06)** Questions.*

- **Date: 2018.09.03** **Pass Mark 50%**

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

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

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.

a. The reversible expansion of a mass of ***0.06 kg*** of air in a cylinder is so controlled that the pressure changes according to the law $p = aV + b$, where a and b are constants. The initial and final pressures are ***15 bar*** and ***1.5 bar***, and the corresponding volumes are ***0.003 m^3*** and ***0.03 m^3***.

   i. Find the heat transferred during the process, stating clearly any assumptions made. (8 marks)

   ii. Sketch the process on ***P-V*** diagram. (6 marks)

b. If the working fluid had been steam instead of air, would the results have been different? Give your reasons. (6 marks)

2. A mass of ***1kg*** of steam is taken through a cyclic non-flow process which consists of two parts. Initially the steam is at a temperature of ***350 ^0C*** and a pressure of ***6 bar***. It undergoes a reversible process which is represented by a straight line on *p-v* diagram so that its final state is specified by a temperature of ***450 ^0C*** and a pressure of ***20 bar***. The steam then undergoes an adiabatic process which returns to its initial state.

   a. Evaluate the net work done during the whole cyclic process. (15 marks)

   b. State whether the second process can be reversible or not, giving reasons. (5 marks)

3.

a. Calculate the cycle efficiency and specific steam consumption of a Rankine cycle (viz. without superheat), working between pressures of ***30 bar*** and ***0.04 bar***. Make necessary assumption for the feed pump work. (13 marks)

b. Recalculate the cycle efficiency and the specific steam consumption, assuming isentropic efficiencies of ***0.80*** for the turbine. (7 marks)

4.

a. A four-cylinder petrol engine has a swept volume of ***2000 cm^3***, and the clearance volume in each cylinder is ***60 cm^3***. Calculate the air standard thermal efficiency. (14 marks)

b. If the induction conditions are ***1 bar*** and ***24^oC***, and the maximum cycle temperature is ***1400^oC***, calculate the mean effective pressure. (6 marks)

5. A composite wall is made up of an external thickness of brickwork ***110 mm*** thick, inside which is a layer of fiberglass ***75 mm*** thick. The fiberglass is faced internally by an insulating board ***25 mm*** thick. The coefficients of thermal conductivity for the three materials are

Brick work	***0.6 W/m K***
Fibreglass	***0.04 W/m K***
Insulating board	***0.06 W/m K***

The surface transfer coefficient of the inside wall is ***2.34 W/m^2 K***, that of the outside wall is ***4.21 W/m^2 K***. Take the internal ambient temperature as ***25^0C*** and the external ambient temperature as ***-10^0C***. Determine

a. The overall transfer coefficient for the wall and using the coefficient (6 marks)

b. The heat lost per hour through unit area (4 marks)

c. The temperature at each interface of the wall (10 marks)

6. In an ideal ***Dual combustion cycle*** the heat transfer during combustion is equally shared between the constant pressure and constant volume parts of the cycle. The volume compression ratio is ***13:1*** and the pressure and temperature at the begging of compression are ***1.03 bar*** and ***40 ^0C*** respectively. The maximum temperature reached during the cycle is ***1600 ^0C***. Calculate

a. The heat transfer to the cycle under constant volume and pressure (6 marks)
b. The heat rejection (4 marks)
c. Work transfer by 1 kg of air per cycle (6 marks)
d. The mean effective pressure (4 marks)

7. In an air compressor, air is compressed according to the law $PV^{1.3} = constant$. The initial conditions of the air is ***1.0 bar***, and ***27 ^0C***. The compressor has a bore of ***200 mm*** and the stroke 0f ***300 mm***. the clearance volume is ***5%*** of the swept volume. If the final pressure is ***10 bar***,

   a. Draw the ***PV*** diagram representing all the processes (2 marks)

   b. calculate

      i. For what length of the stroke air is delivered (5 marks)

      ii. The volume of air delivered per stroke (4 marks)

      iii. The final temperature and change of internal energy after the compression (4 marks)

      iv. The volumetric efficiency (5 marks)

8. A test on a seven-cylinder, 2 stroke engine resulted in the following data: brake power per cylinder***1.62 MW***. The engine has a bore of ***500 mm*** and stroke of ***2050 mm*** and the mechanical efficiency is ***78 %***. At a full load speed of ***124 rev/min***, The engine uses ***1975 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 (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. In a Freaon-12 refrigerator, the Freon leaves the condenser as saturated liquid at ***6.516 bar***. The evaporator temperature is ***-10 ^0C*** and the Freon leaves the compressor as a dry vapour at ***6.516 bar***.

   a. Determine,

      i. Enthalpy before the refrigerant passes through the throttling valve (2 marks)

      ii. Dryness fractions at the evaporator inlet and outlet (4 marks)

      iii. The cooling effect per kg of refrigerant (4 marks)

      iv. The compressor work (4 marks)

      v. COP of the cycle (2 marks)

   b. Draw the ***T – S*** and ***P –H*** diagram for the refrigeration cycle (4 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 Any **SIX (06)** Questions.*
- **Date: 2018.08.31** **Pass Mark 50%**

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

1. a. For two given matrices If $A = \begin{bmatrix} 1 & -2 & 3 \\ 2 & 3 & -1 \\ -3 & 1 & 2 \end{bmatrix}$ and $B = \begin{bmatrix} 1 & 0 & 2 \\ 0 & 1 & 2 \\ 1 & 2 & 0 \end{bmatrix}$

   Find AB and BA (8 marks)

   b. Find the adjoint of A. (8 marks)

   c. Hence find the inverse of A (4 marks)

2. a. Prove that

   i. $Cos2\theta = 2Cos^2\theta - 1 = 1 - 2Sin^2\theta$

   ii. $Sin\,3\theta = 3Sin\theta - 4Sin^3\theta$ (6 marks)

   b. Hence or otherwise find the solutions of the equation

   $4Sin^3\theta - 2Sin^2\theta - 3Sin\theta + 1 = 0$ between 0 and 2π radians. (6 marks)

   c. Two chimneys AB and CD are of equal lengths. A person standing between them in line AC joining there bases observes the elevation of the one near to him to be 45^0. After walking 80 ft. in the direction at right angle to AC he observes their elevation to be $60^0$and 30^0. Find their height and distance apart. (8 marks)

3. a. Evaluate i) $\int x\sin\frac{x}{4}dx$ ii) $\int 5log_e x dx$ iii) $\int 2xe^{2x}dx$ (9 marks)

   b. Find the area of the region R bounded by $y = x^2$, $x = -1$ and $x = -3$. (5 marks)

   c. If R is rotated around x axis find the volume of the solid generated. (6 marks)

4. a. Suppose $y = x^2 - xy$

i. Find the slope of the line tangent to the curve where x = 1.

ii. Find the equation of the line tangent to the curve where x = 1. (6 marks)

b. If $z = \frac{x}{x^2-y^2}$ find all the first order and second order partial derivatives. (8 marks)

c. A rectangular sheet of metal with length 6 meters and width 2 meters is given. Four equal squares are removed from the corners. The sides of this sheet are now turned up to form an open rectangular box. Calculate approximately the height of the box, such that the volume of the box is maximum. (6 marks)

5.

a. Show that $\log_2 12 = 2 + 3\log_8 3$ (5 marks)

b. If $2^x = 3^y = 6^z$, show that $xy = z(x + y)$ (5 marks)

c. Solve the simultaneous equation

$$3^x - 2^{y+2} = 4$$
$$3^{x-1} + 2^{y+1} = 3$$ (5 marks)

d. Determine the partial fractions of $\frac{x^2 + 2x + 1}{(x-2)(2x^2 + x - 3)}$ (5 marks)

6. A quadratic function is defined by

$$f(x) = x^2 + (k+1)x + 4$$

where k is a constant. It is given that the equation f(x) =0 has two distinct real roots.

a. Find the set of values that k can take. (6 marks)

b. For the case where $k = -5$,

i. express $f(x)$ in the form $(x-a)^2 + b$, stating the values of a and b, and hence write down the least value taken by $f(x)$, (6 marks)

ii. Solve the equation $f(x) = 0$, expressing your answer in terms of surds, simplified as far as possible. (4 marks)

iii. Sketch the quadratic function *f(x)* (4 marks)

7.

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

i. $2z_1 - z_2 + 3z_3$

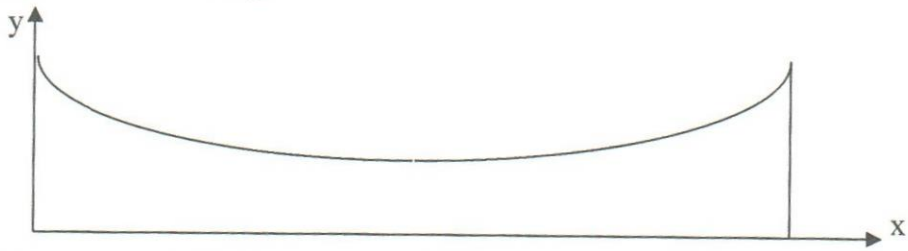
ii. $z_1 \times (z_2 - 2z_3)$

iii. $\frac{iz_1 + z_3}{z_2}$ (12 marks)

Hint: $r\angle\theta \equiv r(Cos\,\theta + i\,Sin\,\theta)$

b. Find the square root of $3 - i$ (8 marks)

8. Figure represents a lamina made by coordinates given in the table below. Use the table and figure for the followings



x(m)	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0
y(m)	1	0.85	0.75	0.7	0.65	0.62	0.6	0.58	0.55	0.58	0.6	0.62	0.65	0.7	0.75	0.85	1

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)

9. For the function, $f(x) = 2x^4 - 4x^2$

a. Find all the real roots of the function, *f(x)* (4 marks)

b. Find all the stationary values of the function, *f(x)* and the nature of them (6 marks)

c. Hence, plot the function for all real values of x (6 marks)

d. Estimate the area under the function in the domain of $-\sqrt{2} \le x \le \sqrt{2}$ (4 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

ELECTROTECHNOLOGY

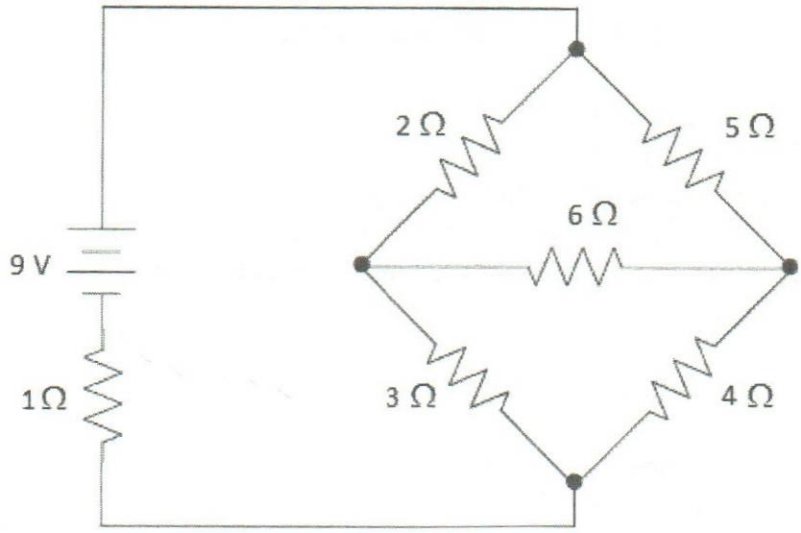
- **Time Allowed - Three Hours**
- *Answer Four (04) Questions From* ***Part A****, and Two (2) Questions From* ***Part B.***
- **Date: 2018.08.30** **Pass Mark 50%**

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

Part A

1. a) State and explain the Kirchhoff's laws with regard to electrical circuits. (08 marks)

   b) Calculate the currents in the various branches of the network given below. (12 marks)



2. a) Explain the term 'Reluctance' with respect to a magnetic circuit and express it in terms of usual parameters. (06 marks)

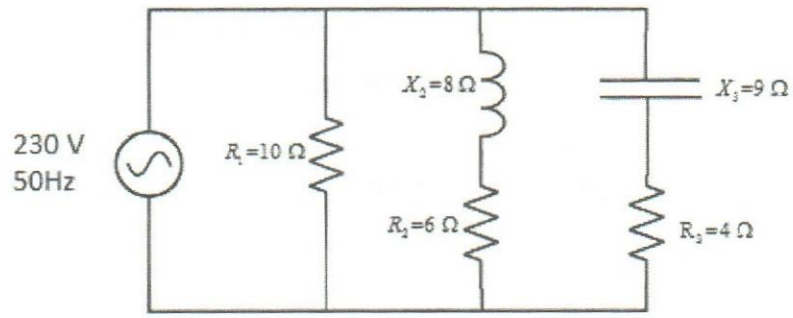
   b) A flux density of 1.2T is required in 3mm air gap of an electromagnet wound with 500 turns of wire and having an iron (μ_r = 1000) path of 125cm.

      i. Make necessary assumptions and calculate the current required to achieve the given flux density in the air gap. (Permeability of air, $\mu_0 = 1.257 \times 10^{-6}$ H/m) (10 marks)

      ii. Given that the cross-sectional diameter of magnet is 2cm, calculate the reluctance of the circuit. (04 marks)

3. a) With the aid of phasor diagrams, explain the phase difference between voltage and current waveforms across an inductor and a capacitor. (05 marks)

b) Refer the following circuit and calculate the following;



i. Current and power factor of each branch (6 marks)

ii. Total current, power factor and power consumption (6 marks)

iii. Equivalent impedance of the circuit (3 marks)

4.

a) A 100 V, 50 Hz single phase a.c. supply is connected in series to a resistance of 250 Ω, an inductance of 650 mH and a capacitance of 1.5 μF . Calculate the

i. Inductive reactance (03 marks)

ii. Capacitive reactance (03 marks)

iii. Circuit impedance (03 marks)

iv. Current with reference to the supply voltage (03 marks)

b) A single-phase motor connected to 400V, 50 Hz supply takes 31.7 A at a power factor of 0.7 lagging. Calculate the capacitance required in parallel with the motor to raise the power factor to 0.9 lagging. (08 marks)

5.

a) Explain the methods of excitation in DC generators. (05 marks)

b) Let

P – Number of poles of the DC generator

ϕ – Flux per pole in Weber.

Z – Total number of armature conductors.

N – Speed of armature in revolution per minute (r.p.m).

A – Number of parallel paths in the armature winding.

Derive the e.m.f. equation of DC generator at N r.p.m speed in terms of above mentioned (05 marks)

c) A 75 kW shunt generator is operated at 220V. The stray losses are 1800W and shunt field circuit draws 5.25 A. The armature circuit has a resistance of 0.035 Ω and the brushes voltage drop is 2V. Calculate efficiency at rated load. (10 marks)

6.

a) What are the difference between wave and lap armature windings. (04 marks)

b) Briefly explain power conversion stages in D.C. motor with power losses. (04 marks)

c) A 220V shunt motor takes a total current of 80A and runs at 800r.p.m. Shunt field resistance and armature resistance are 50 Ω and 0.1 Ω respectively. If iron and friction losses are 1600W. Determine

i. Copper losses (04 marks)

ii. Armature torque (04 marks)

iii. Efficiency (04 marks)

Part B

7.

a) With regards to Alternators state two methods how excitation of the rotor is provided, one in detail. (10 marks)

b) Explain the function of an Automatic voltage regulator using a block diagram. (10 marks)

8.

a) State 3 reasons why high voltage installations are used onboard ships. (06 marks)

b) Explain how high voltage electrical equipment can be released for maintenance. State what permits need to be done. (07 marks)

c) State what precautions are need to be carried out when working in High Voltage components. (07 marks)

9.

a) Briefly explain the functions of the transformer with the help of sketch. (05 marks)

b) Briefly explain the purpose of an instrument transformer. (04 marks)

c) What are the types of instrument transformers found on main switch board? (03 marks)

d) Sketch and describe how instrument transformers are connected in main switch board. (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**

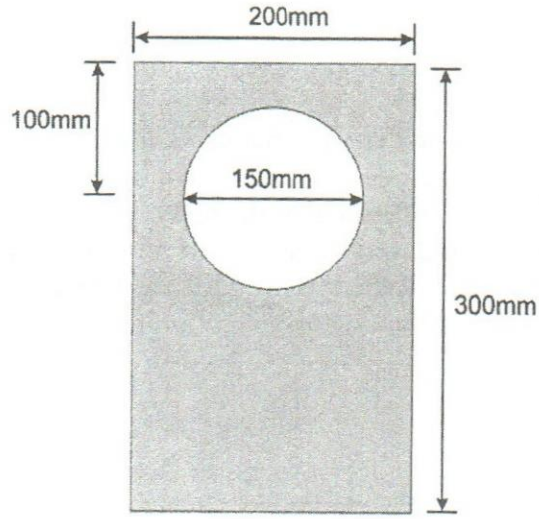
Date: 2018.08.29 **Pass mark: 50%**

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

1

1.1. State and prove parallel axis theorem (6 marks)

1.2. Find the moment of inertia of a hollow section shown in below figure about a horizontal axis passing through its center of gravity. (14 marks)



2

2.1. Derive four linear motion equations and deduce them to represent the maximum height and total time taken for the vertical motion of an object under gravity. (6 marks)

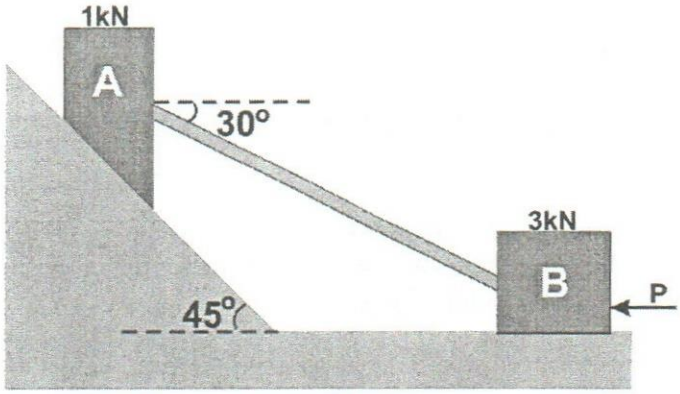
2.2. A cage descends in a mine shaft with an acceleration of 0.5 m/s^2. After the cage has travelled 25m, a stone is dropped from the top of the shaft. Determine;

a. the time taken by the stone to hit the cage (7 marks)
b. distance travelled by the cage before impact (7 marks)

3

3.1. What is coefficient of friction and angle of repose? (4 marks)

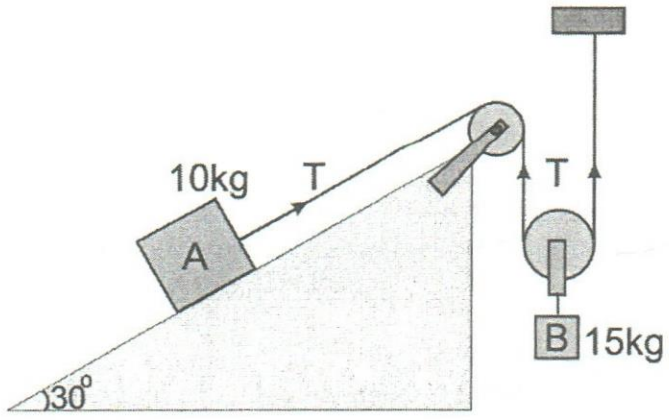
3.2. A block "A" weighing 1kN rests on a rough inclined plane whose inclination to the horizontal is 45^0. This block is connected to another block "B" weighing 3kN rests on a rough horizontal plane by a weightless rigid bar inclined at an angle of 30^0 to the horizontal as shown in the below figure. Find horizontal force "p" required to be applied to the block "B" just to move the block "A" upward direction. Assume angle of limiting friction as 15^0 at all surface where there is sliding. (16 marks)



4

4.1. State three newton laws and derive F=ma using the second law (6 marks)

4.2. Determine the resulting acceleration of the body "A" shown in below figure assuming the pulleys to be smooth and weightless. The friction coefficient between the block "A" and the inclined plan is 0.2. If the system starts from rest, determine the velocity of the body "A" after 10 seconds. (14 marks)



5

5.1. Describe the relationship between the work done, energy and power (5 marks)

5.2. An army truck of mass 5 tons has tractive resistance of 150 N/tone. Find the power required to propel the truck at a uniform speed of 36 km/h;

a. Up an incline of 1 in 100 (5 marks)
b. On a level track (5 marks)
c. Down an incline of 1 in 100 (5 marks)

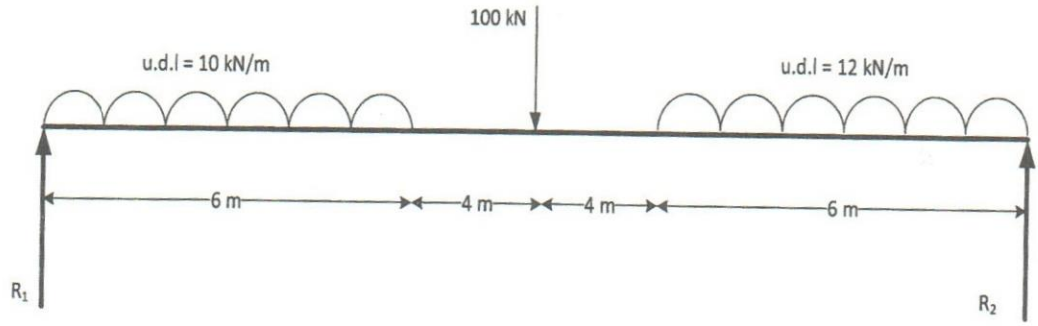
6

A multi disc clutch use total of six contact surfaces; and the contact surface of the clutch has an outside diameter of 360 mm and inside diameter of 220mm. If the clutch is newly used one for the operation, find the maximum axial thrust acting on the clutch, when it is running at 1600 r.p.m and transmitting 35kW. Take coefficient of friction as 0.35.

(20 Marks)

7 Below figure shows the loading applied on the simply supported beam. Two UDLs are acting on the beam as shown;

a. Determine the reactions, R1 and R2. (03 marks)
b. Draw the Bending moment and Shear force diagram (15 marks)
c. Determine maximum bending moment and point where it occur. (02 marks)



8

8.1. Bernuoil's equation gives the total head at point in a fluid flow. Define the terms used in this equation with SI unit of each term. (4marks)

8.2. Smooth pipe consisting a uniform diameter of 50 cm, a pressure of 75 kPa was observed at section "A", at an elevation of 12 m. The section B at an elevation of 32 m, pressure was recorded as 55 kPa. The mean velocity of flow through a pipe is 1.5 ms^{-1}. If water is passing through the pipe, Find;

a. Flow rate (3 marks)
b. Direction of flow (3 marks)
c. Head loss (10 marks)

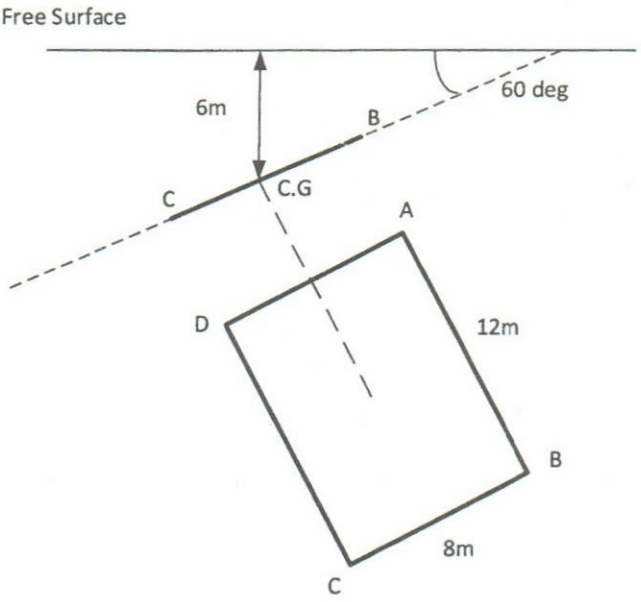
9

9.1. What is center of pressure? (05 marks)

9.2. Figure shows a rectangular sheet, ABCD immersed in the water such that it makes 60^0 inclination with free surface. The center of gravity of the sheet is at a vertical depth of 6 m from the free surface.

a. Determine the total pressure force acting on the plate (08 marks)

b. Position of center of pressure (07 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

THERMODYNAMICS

- **TIME ALLOWED - THREE HOURS**
- **Answer SIX questions only**
- **Date: 2018.05.02** **Pass marks: 50%**

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

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

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.

a. Define the ***calorific value*** of a fuel (2 marks)

b. An oil fuel composed of ***82 %*** Carbon and ***15 %*** Hydrogen, ***3%*** Oxygen. Determine

i. The calorific values (HCV and LCV) of the fuel if the calorific values of Carbon and Hydrogen are ***33.7 MJ.kg*** and ***144MJ/kg*** respectively. (8 marks)

ii. The stoichiometric air fuel ratio taking the molecular mass of ***C, H*** and ***O 12, 1*** and ***16*** respectively (4 marks)

c. Furnace coal has a heat of ***34 MJ/kg***. assuming ***70 %*** of the heat is useful, how many kg of coal are required to produce ***600 kg/h*** of steam at ***10 bar*** and ***400 ^{0}C*** from water at ***27 ^{0}C***. (6 marks)

2. ***0.65 kg*** of air at ***14 bar*** and ***210^0 C*** is expanded to four times the initial volume according to the law ***$PV^{1.23}$= constant***. Determine:

a. The initial and final volume (4 marks)

b. Final temperature and pressure (4 marks)

c. Work done (3 marks)

d. Change in internal energy (3 marks)

e. Heat transfer (3 marks)

f. Change in entropy (3 marks)

3.

a. A four-cylinder petrol engine has a swept volume of ***2000 cm³***, and the clearance volume in each cylinder is ***60 cm³***.Calculate the air standard thermal efficiency. (14 marks)

b. If the induction conditions are ***1 bar*** and ***24 ^{0}C***, and the maximum cycle temperature is ***1400 ^{0}C***, calculate the mean effective pressure. (6 marks)

4. The pressure, volume and temperature at the beginning of the compression of a constant volume cycle (Otto cycle) are ***105 kPa***, ***0.002 m³*** and ***25 ^{0}C*** respectively. The maximum temperature of the cycle is ***1250 ^{0}C***. The volume ratio of the cycle is ***8:1***. The cycle is repeated ***2000 times/min***. Determine for the cycle

   a. The theoretical output in kW (8 marks)

   b. The thermal efficiency (4 marks)

   c. The mean effective pressure (5 marks)

   d. The Carnot efficiency within the same temperature limits (3 marks)

5. In an ideal diesel cycle the volume compression ratio is ***14:1*** and heat supply occurs during ***10%*** of the swept volume. The conditions at the beginning of compression are ***35°C*** and ***1bar***. Calculate:

   a. the temperatures and pressures at the remaining cardinal points of the cycle. (13 marks)

   b. the thermal efficiency of the cycle. (7 marks)

6. Water is the working fluid in a power plant operated by Rankine cycle. The superheated steam enters the turbine at ***100 bar***, ***500°C***. The condenser pressure is ***0.01 bar***. The net power output of the cycle is ***300 MW***.

   a. Determine

      i. The quality of the steam after the expansion in the turbine (3 marks)

      ii. The rate of steam transfer through the turbine (3 marks)

      iii. The rate of heat transfer to passing through the boiler (3 marks)

      iv. The thermal efficiency (3 marks)

   b. Estimate the quality of steam after the expansion in the turbine if the isentropic efficiency is 0.8 (Hint: ratio between the actual and isentropic enthalpy drop through the turbine) (4 marks)

   c. Draw the T S diagram (4 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: 2018.04.27** **Pass marks: 50%**

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

1.

a. Find the value of $\dfrac{\log 3\sqrt{3}+\log 2\sqrt{2}-\log 5\sqrt{5}}{\log 1.2}$ by laws of logarithm (4 marks)

b. Resolve into partial fractions $\dfrac{x^2+2x-3}{\left(x^2+2\right)\left(x-1\right)^2}$ (5 marks)

c. Factorize the expression completely, $f(x)=x^3-2x^2-5x+6$ (5 marks)

d. Find the solution sets of the inequality, $\left|x^2-4x\right|\le x$ (6 marks)

2. A quadratic function is defined by $f(x)\equiv x^2-2x-3$.

a. Find the set of values of x for which $f(x)>7$. (5 marks)

b. Find the set of values of k for which $f(x)=kx$ has no 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 $\dfrac{1}{f(x)}$. (5 marks)

d. Sketch the curve $y=f(x)$, showing any intercept with the coordinate axes. (5 marks)

3.

a. Find all the roots of the function, $(x-1)^3-8=0$ and mark them in an Argand diagram (6 marks)

b. Estimate the square root of $\dfrac{1+i}{1-3i}$ (6 marks)

c. Simplify the following complex numbers into $a+bi$ where $a,b\in\mathbb{R}$ and $i^2=-1$

i. $\left(2\angle\frac{\pi}{2}\right)\times\left(3\sqrt{2}\angle\frac{\pi}{4}\right)$ (4 marks)

ii. $\left(2\sqrt{2}\angle\frac{3\pi}{4}\right)\Big/\left(2\angle\frac{\pi}{3}\right)$ (4 marks)

Hint: $r\angle\theta\equiv r\,Cos\,\theta+i\,Sin\,\theta$

4.

a. For two given matrices If $A=\begin{pmatrix}1&0&2\\0&1&2\\1&2&0\end{pmatrix}$ and $B=\begin{pmatrix}1&1&2\\2&-1&3\\3&-1&-1\end{pmatrix}$ find AB and AB^T

(8 marks)

b. Find the adjoint of B. (8 marks)

c. Hence find the inverse of B (4 marks)

5.

a. Prove following identities

i. $\dfrac{\text{Cot}\,x+\text{Cosec}\,y}{\text{Tan}\,y+\text{Tan}\,x\,\text{Sec}\,y}=\text{Cot}\,x\,\text{Cot}\,y$ (4 marks)

ii. $\text{Tan}\,\theta+\text{Cot}\,\theta=\text{Sec}\,\theta\,\text{Cosec}\,\theta$ (3 marks)

b. Find the solution of the equation $4Sin^3\theta-2Sin^2\theta-3Sin\theta+1=0$ (6 marks)

c. From one point the angle of elevation of a church spire is 38^0. From a point 50 ft. further away it is 29^0. Determine the height of the spire in ft. and cm. (7 marks)

6.

a. Differentiate the following function with respect to x

i. $y=5x^{-3}+\dfrac{7}{x}+\dfrac{2x^6}{3}-9x+26$ (4 marks)

ii. $y=2x\ln\left(\dfrac{2}{x}\right)$ (4 marks)

b. If $z=\dfrac{xy}{x-y}$ show that $\dfrac{\partial^2 z}{\partial x^2}+2\dfrac{\partial^2 z}{\partial x\partial y}+\dfrac{\partial^2 z}{\partial y^2}=\dfrac{2z}{xy}$ (8 marks)

c. Two nonnegative numbers have sum 60. What are the numbers if the product of one of them and the square of the other is maximum? (4 marks)

7. A single stage single acting air compressor takes in air at ***1 bar*** and ***298 K*** and compressed it to ***12 bar*** and delivers at a rate of ***0.15 m^3/s***. The compression and expansion follows the index ***1.3***. If the clearance volume is ***8 %*** of the swept volume and the swept volume is ***14500 cm^3***, estimate

   a. The temperature at the end of compression and change of internal energy (5 marks)

   b. The power required (5 marks)

   c. Speed of the compressor (5 marks)

   d. The volumetric efficiency (5 marks)

8. A test on a six-cylinder, 2 stroke engine resulted in the following data: brake power with all cylinders working ***31.7 MW***. The engine has a bore of ***980 mm*** and stroke of ***2660 mm*** and the mean effective pressure is ***17.39 bar***. At a full load speed of ***104 rev/min***, The engine uses ***67.2 kg*** of fuel per minute and calorific value of fuel is ***42.5 MJ/kg***.

   Estimate

   i. The indicated power, friction power (6 marks)

   ii. mechanical efficiency (4 marks)

   iii. Brake specific fuel consumption and indicated specific fuel consumption (5 marks)

   iv. Indicated thermal efficiency and brake thermal efficiency (5 marks)

9. An ***Ammonia*** refrigerator operates between evaporating and condensing temperatures of ***-16 ^0C*** and ***50 ^0C*** respectively. The vapour is dry saturated at the compressor inlet, the compression process is isentropic and there is no under cooling of the condensate. Calculate:

   a. The refrigerating effect ***per kg.*** (7 marks)

   b. The mass flow of refrigerant ***per kW of refrigeration*** (7 marks)

   c. Power input per ***kW*** of refrigerant. (6 marks)

7.

a. Show that $\int_0^2 \frac{1}{1+x}\,dx = \ln 3$ (4 marks)

b. Use 1/3 Simpson's rule to interpolate a value for the integration $\int_0^2 \frac{1}{1+x}\,dx$ for five ordinates (n = 10). (12 marks)

c. Hence determine the value of $\ln 3$ for four decimal places. (4 marks)

8.

a. Determine the integrals with respect to x

i. $\int \frac{x^2-1}{x+2}\,dx$ (5 marks)

ii. $\int x \tan^{-1} x\,dx$ (5 marks)

b. Show that $\int_{1/2}^{1} x \ln\left(\frac{1}{x}\right) dx = \frac{3}{16} - \frac{1}{8}\ln 2$ (5 marks)

c. Calculate the volume of the solid formed by revolving completely the by the curves, region bounded $y = -x^2 + 8$ and $y = x^2$ about the x –axis. (5 marks)

9.

a. Locate and classify all stationary points of $f(x) = x^3 - 5x^2 + 6x$ (8 marks)

b. Sketch the curve of $f(x) = x^3 - 5x^2 + 6x$ (6 marks)

c. Find the area bounded by the curve and x-axis from $x = 0$ to $x = 3$ (6 marks)

27

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: 2018.04.26** **Pass marks: 50%**

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

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Part A

1.

a) Express Lenz's law and Faraday's laws. (2 marks)

b) Explain the mutually induced electro motive force. (2 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.

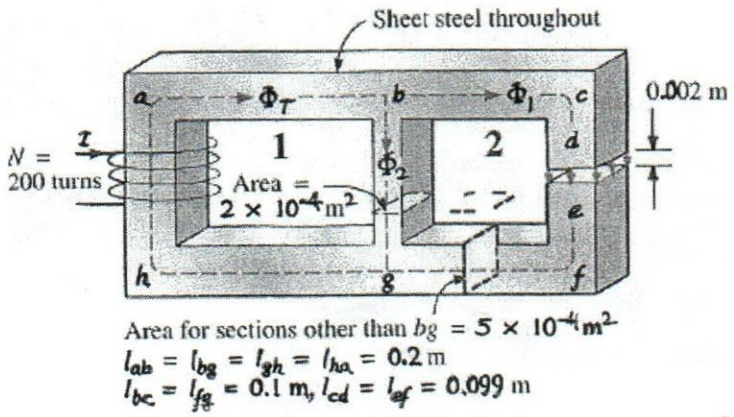
i. Calculate the mutual inductance between the coils. (6 marks)

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? (6 marks)

2.

a) Define the field intensity, H of a magnetic circuit and explain how it is related to flux density, B across different material in the circuit with the aid of appropriate equations. (4 marks)

b) Refer the magnetic circuit given in Fig. in usual notations



Area for sections other than $bg = 5 \times 10^{-4} m^2$

$l_{ab} = l_{bg} = l_{gh} = l_{ha} = 0.2$ m

$l_{bc} = l_{fg} = 0.1$ m, $l_{cd} = l_{ef} = 0.099$ m

i. Assuming that the relative permeability of steel is 150 in general, calculate the ratio between Φ1 and Φ2 (5 marks)

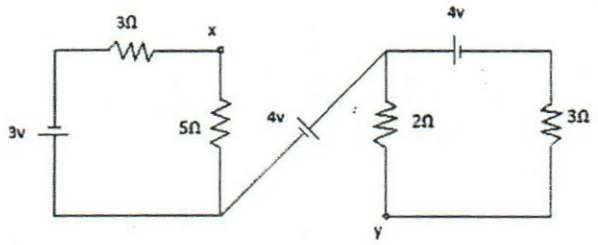
ii. Determine the current required to generate a total flux of $8.5\times10^{-8}Wb$. (Permeability of air, $\mu_0 = 1.257\times10^{-6}H/m$) (5 marks)

iii. Hence, calculate the reluctance of the overall circuit. (2 marks)

3.

a) Express Kirchhoff current and voltage laws (4 marks)

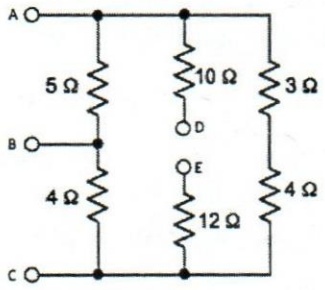
b) Calculate potential difference between X and Y. (6 marks)



c) Determine the resistance (6 marks)

i. R_{DE}

ii. R_{AC}, if B, D and E are connected in following resisters network.



4.

a) Explain the term 'reactance' and express that of an inductor and a capacitor in terms of appropriate quantities. (6 marks)

b) A 15Ω resistor, 50mH inductor and 200μF capacitor are connected in parallel to form a complex load and is connected to a 220V 60Hz power supply

i. Calculate the equivalent impedance of the load. (6 marks)

ii. Determine the (active) power output of the load. (4 marks)

5.

a) Draw the equivalent circuit of a DC shunt motor and develop the torque-speed characteristics using basic equations. (5 marks)

b) 100V, 1kW DC shunt motor with an armature resistance of 1.25Ω rotates at 600 rpm. A variable field resistance draws a current of 1A at no load. Given that the field resistance is reduced by 50% at full load, Neglecting the mechanical and iron losses, calculate the following at full load

i. Armature current (4 marks)
ii. Torque and speed (4 marks)
iii. Electrical efficiency (3 marks)

6. A series RLC circuit with $R = 10.0\ \Omega$, $L = 400\ mH$ and $C = 2.0\ \mu F$ is connected to an AC voltage source which has a maximum amplitude $V_0 = 100\ V$.

a) What is the resonant frequency? (6 marks)
b) Find the r.m.s current at resonance. (5 marks)
c) Let the driving frequency be $\omega_0 = 4000\ rad/s$. Compute X_C, X_L, Z and ϕ. (5 marks)

Part B

7. With reference to insulation testing of electrical equipment:

a) State the purpose of insulation testing and why it is carried out on the regular basis. (6 marks)
b) Describe the procedure for taking a set of insulation readings on an electric. (6 marks)
c) State the precautions to be taken when testing an a.c. generator. (4 marks)

8.

a) State Two indications that single phasing has occurred in the circuitry of a large 3-phase induction motor. (2 marks)
b) Explain how the effects of single phasing may differ in EACH of the following:
i. Star (2 marks.)
ii. Delta (2 marks.)
c) Explain why single phasing in delta configuration is more serious than in star configuration, describing a means to overcome this disadvantage (4 marks.)
d) State the principles of synchronization for AC generators. (6 marks)

9. with reference to high voltage systems on board ship.

a) State the maximum value that is considered to be high voltage. (2 marks)
b) Explain how earthing is achieved in high voltage generators. (4 marks)
c) State three advantages of this system. (5 marks)
d) State three disadvantages of this system. (5 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 SIX questions only**
- **Date: 2018.04.25** **Pass marks: 50%**

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

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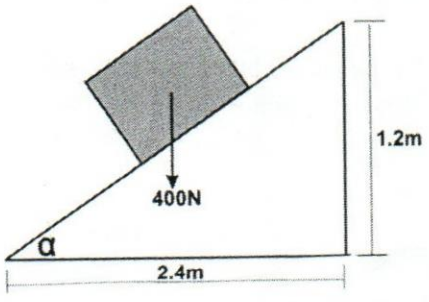
Density of Water – 1000 kgm^{-3} | Gravitational acceleration – 9.81 ms^{-2}
Density of Sea Water – 1100 kgm^{-3}

1.

a. "friction is a self-adjusting force" explain the statement briefly. And show the relationship between friction angle and coefficient of friction with the help of a suitable figure.
(6 marks)

b. An inclined plane as shown in the figure is used to unload slowly a body weighing 400N from a truck 1.2m high into the ground. The coefficient of friction between the underside of the body and the plank is 0.3. State whether it is necessary to push the body down the plane or hold it back from sliding down. What minimum force is required parallel to the plane for this purpose? (14 marks)

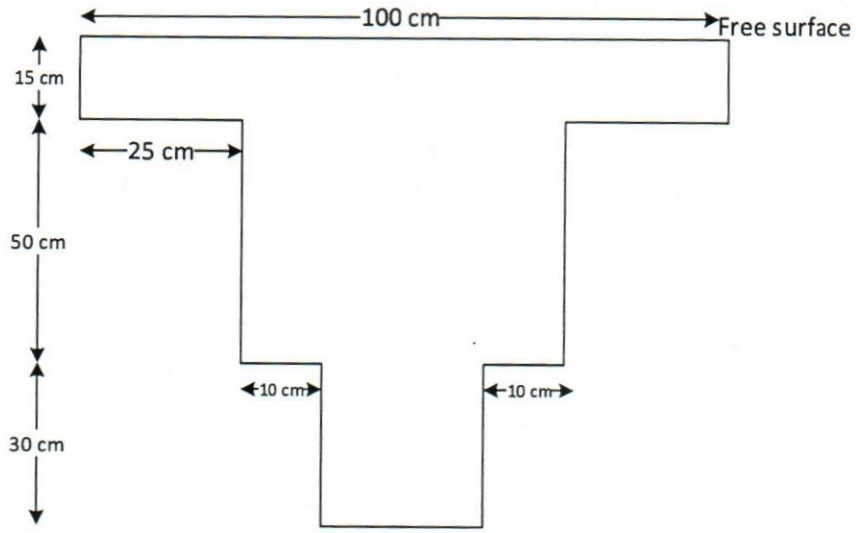


2.

a. State three Newton's Laws of motion and obtain the "F = ma" equation from second law.
(6 marks)

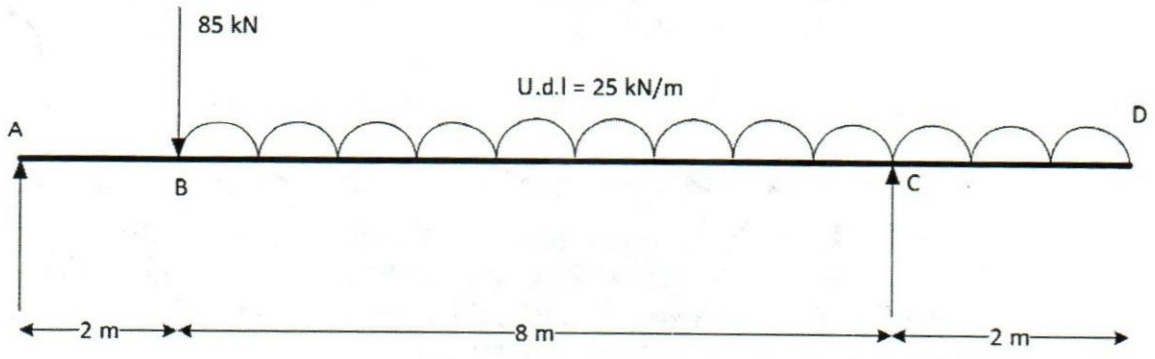
b. A truck weighing 6 kN moves freely (engine is not running) at 36km/h down a slope of 1 in 40. The road resistance at this speed is just being sufficient to prevent any acceleration of the truck. Find the road resistance per kN weight of truck. What power will the engine have to exert to run up the same slope at double the speed when the road resistance remains the same?
(14 marks)

3. Figure shows a symmetric metal sheet which is vertically immersed into a water such that its top edge is touching with free surface. Determine
   a. Total pressure force (10 marks)
   b. Position of center of pressure. (10 marks)



4.
   a. Define "work done" and hence derive equations for "potential energy" and "kinetic energy" using suitable notations. (6 marks)
   b. A body weighing 20N is projected up a 20^0 inclined plane with a velocity of 12m/s. If the coefficient of friction is 0.15, find;
      i. The maximum distance "S", that the body will move up the inclined plane.
      ii. Velocity of the body when it returns to its original position. (14 marks)

5. The loading status of the simply supported beam is shown in figure below. Two reactions at acting at A and C and point load of 85 kN is acting at point B.



   a. Determine two reactions at A and C (05 marks)
   b. Draw the bending moment diagram and shear force diagram (10 marks)
   c. Determine the location where maximum bending moment occur and its magnitude (05 marks)

6.

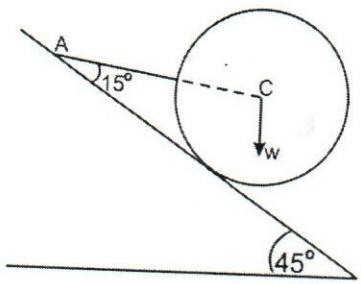
a. Define terms used in a Bernouli's equation. (05 marks)

b. The smooth pipe with uniform diameter of 150 cm and pressure at location A is 60 kPa and at elevation of 15 m. B is located at elevation of 25 m and shows the pressure of 30 kPa. The flow rate through a pipe is 10 m^3/sec. Determine the direction of flow and total head loss. (15 marks)

7.

a. State Lami's theorem and provide graphical representation of it. (4 Marks)

b. A roller of weight 1 kN rests on a smooth plane. It is kept from rolling down the plane by a string AC as shown in the figure. Find the tension in the string and the reaction at the point of contact. (16 Marks)



8.

a. State and prove Archimedes' principle using suitable notations. (5 marks)

b. A block of weight 45 N has part of its volume submerged in a beaker of water. The block is partially supported by a string of fixed length that is tied to a support above the beaker. When 80% of the block's volume is submerged, the tension in the string is 5 N.

i. What is the magnitude of the buoyant force acting on the block? (3 marks)

ii. Water is steadily removed from the beaker, causing the block to become less submerged. The string breaks when its tension exceeds 35 N. What percent of the block's volume is submerged at the moment the string breaks? (6 marks)

iii. After the string breaks, the block comes to a new equilibrium position in the beaker. At equilibrium, what percent of the block's volume is submerged? (6 marks)

9.

a. Define "mean velocity" and "average velocity" and derive the four translational motion equations. (6 marks)

b. A passenger in a bus, which travels in a straight road with a constant velocity of 18 km/h, rings the bell at point 'A' to get-off from the bus at the bus halt 'H' which is $6\frac{1}{4}$ m away from 'A'. The driver start applying the brakes at 'A' and the decelerations to be f, 2f, 3f between points AB, BC & CH where AB=BC=CH. Find the decelerations between AB, BC and CH using a velocity –time graph. (14 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: 2018.01.05**

Pass marks: 50%

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

1.

a. If $a = \log\frac{10}{9}, b = \log\frac{25}{24}$ and $c = \log\frac{81}{80}$, show that $7a - 2b + 3c = \log 2$ (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. Find vertical and horizontal asymptotes of $f(x) = 3x^5 - 5x^3$ if any (5 Marks)

b. Locate and classify all stationary points of $f(x) = 3x^5 - 5x^3$ (8 Marks)

c. Sketch the curve of the function (7 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

a. Show that $Z = 1 + \frac{Sin\theta}{1 + Cos\theta}i$ (5 marks)

b. Determine $|Z|$ and Arg (Z) (5 marks)

c. Show that $Z.\overline{Z} = \frac{2}{1 + Cos\theta}$ (5 marks)

d. Hence, find the Z^{-1} (5 marks)

4.

a. For two given matrices If $A = \begin{bmatrix} 1 & 1 & 2 \\ 2 & -1 & 3 \\ 3 & -1 & -1 \end{bmatrix}$ and $B = \begin{bmatrix} 1 & 2 & 3 \\ -1 & 0 & 2 \\ 2 & 1 & -0 \end{bmatrix}$

Show that $AB \neq BA$ (8 Marks)

b. Find the adjoint of A. (8 Marks)

c. Hence find the inverse of A (4 Marks)

5.

a. Without using tables find the values of Sin 15 ^{0}, Cos 15 ^{0} and Tan 15 ^{0} (6 Marks)

b. Prove following identities (6 Marks)

i. $\dfrac{Cos^2 x}{(1-Sinx)^2} = (Sec\,x + Tan\,x)^2$

ii. $Coec\,x - Sin\,x = Cot\,x\,Cos\,x$

c. An airplane flies 180 miles from point X at a bearing of 125 degrees, and then turns and flies at a bearing of 230 degrees for 100 miles (Bearings are measured clockwise from North). How far is the plane from point X? (8 Marks)

6.

a. Differentiate the following functions with respect to x

i. $y = \dfrac{\sin 2x}{\sqrt{x}}$ (4 marks)

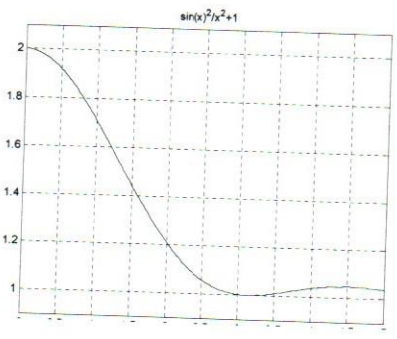
ii. $y^2 + y\,Cos\,x = 0$ (4 marks)

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

(6 marks)

c. If $x = t + \cos t$, $y = \sin t$, estimate $\dfrac{dy}{dx}$ and $\dfrac{d^2y}{dx^2}$ when $t = \dfrac{\pi}{4}$ (6 marks)

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



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.

a. Evaluate

i. $\int x Cos\, x\, dx$ (4 marks)

ii. $\int x \ln x\, dx$ (4 marks)

b. Find the area bounded by the curve $y = x^3$, $x = -2$ and $x = 1$. (4 marks)

c. Show that $\int_0^{\pi/2} x \sin^2 x\, dx = \frac{1}{16}(\pi^2 + 4)$ (8 marks)

Hint: $\sin^2 \theta = \frac{1}{2}(1 - \cos 2\theta)$

9.

a. Suppose $y = 3x^2$. Find the slope of the line tangent to the curve where x = 1. (4 Marks)

b. If $z = \frac{xy}{x+y}$ find first order and second order partial derivatives (8 Marks)

c. If $u = e^{xyz}$ find $\frac{\partial^2 u}{\partial x \partial y \partial z}$ (8 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

MARINE ENGINEERING DRAWING

- **TIME ALLOWED - FOUR HOURS**
- **Date: 2018.01.04**

Pass marks: 50%

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

Details of a **Plug cock** are shown in the figure. **Plug Cock** is a valve where full flow is through a hole in a tapered plug. Rotating the plug 90° completely stops the flow. By using the **First Angle Projection**, draw the following two views of the assembled **Plug cock**:

(a) A view in **half section** showing the outside view on the left of the vertical centre line and a section on the right hand side, the position of the valve body being similar to that shown on the given detail. The valve should be in **closed** position.

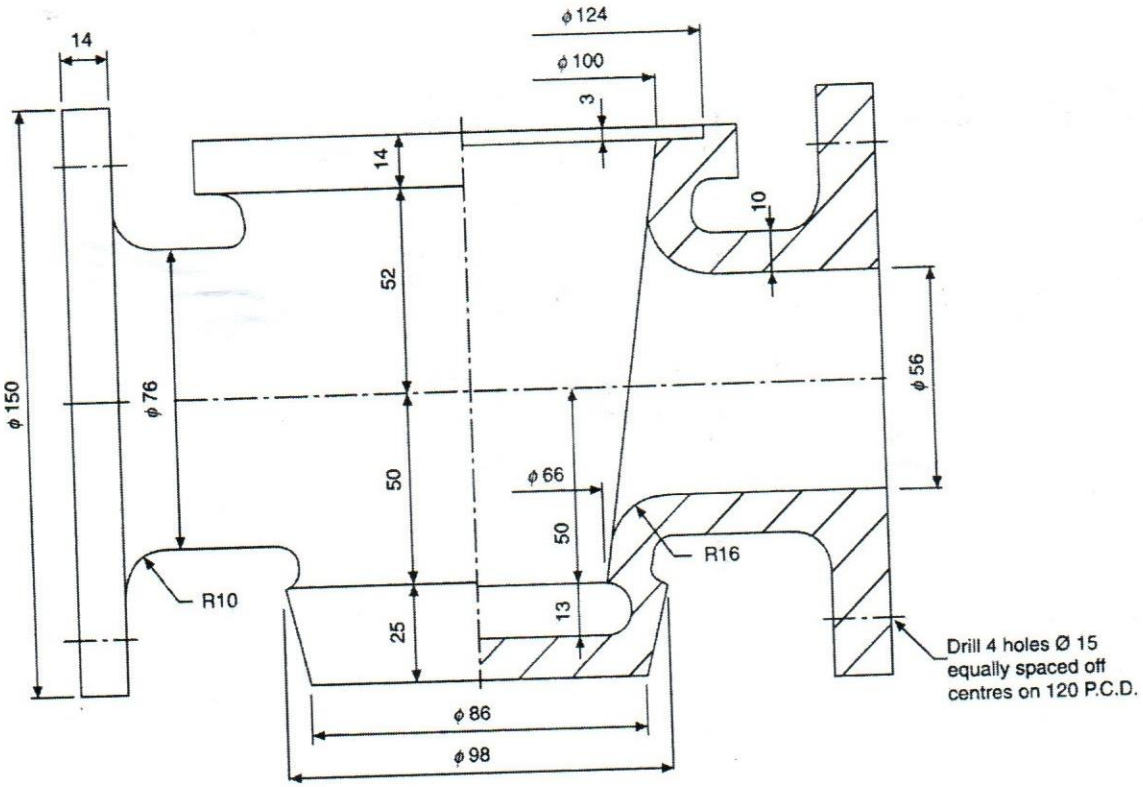
(b) An outside end view projected to the right of (a)

Suitable dimensions should be estimated where not provided. Hidden details are not required in either view. Include on your assembly suitable nuts and bolts and washers where applicable. Between the valve body and cover include a joint ring of thickness 2 mm. The gland should be positioned entering 10 mm into the valve cover.

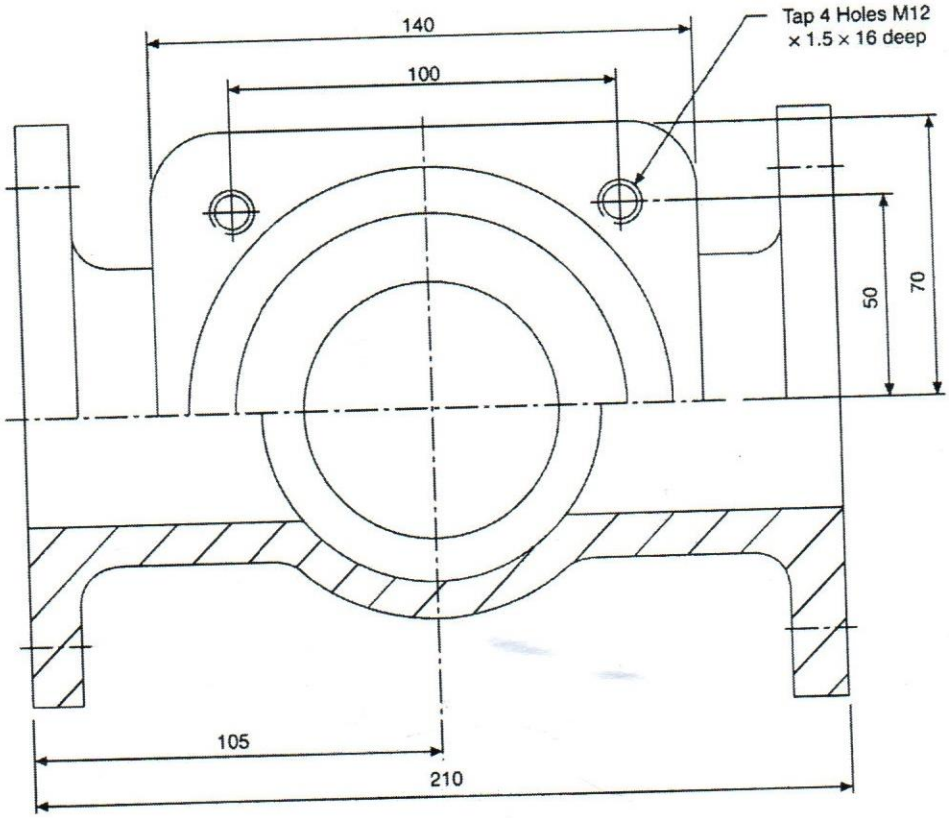
Complete the drawing by including the title, projection symbol, dimensions and a list of materials of parts.

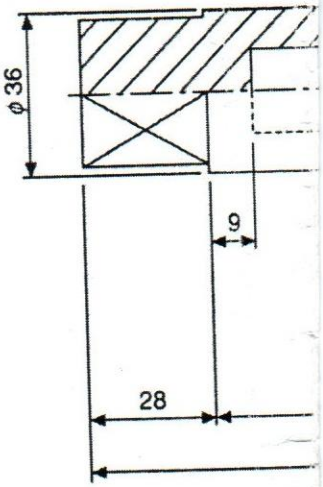
Marking System

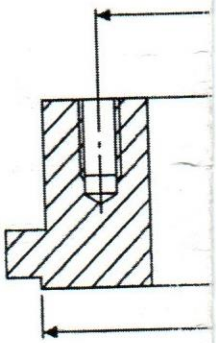
(a) Assembling accuracy of view (a)	(45 marks)
(b) Assembling accuracy of view (b)	(30 marks)
(c) Optimization of space	(05 marks)
(d) Dimensioning (at least 12 dimensions correctly)	(05 marks)
(e) List of materials of parts	(05 marks)
(f) Title block, projection symbol, lettering	(05 marks)
(g) Final appearance, neatness	(05 marks)

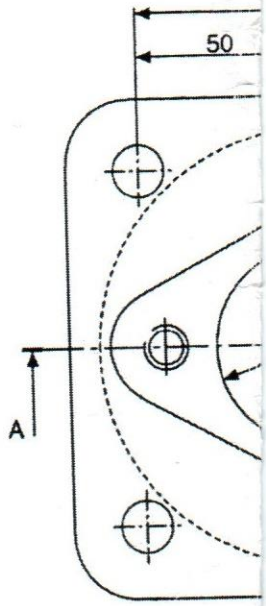


1 Valve body - Cast Steel

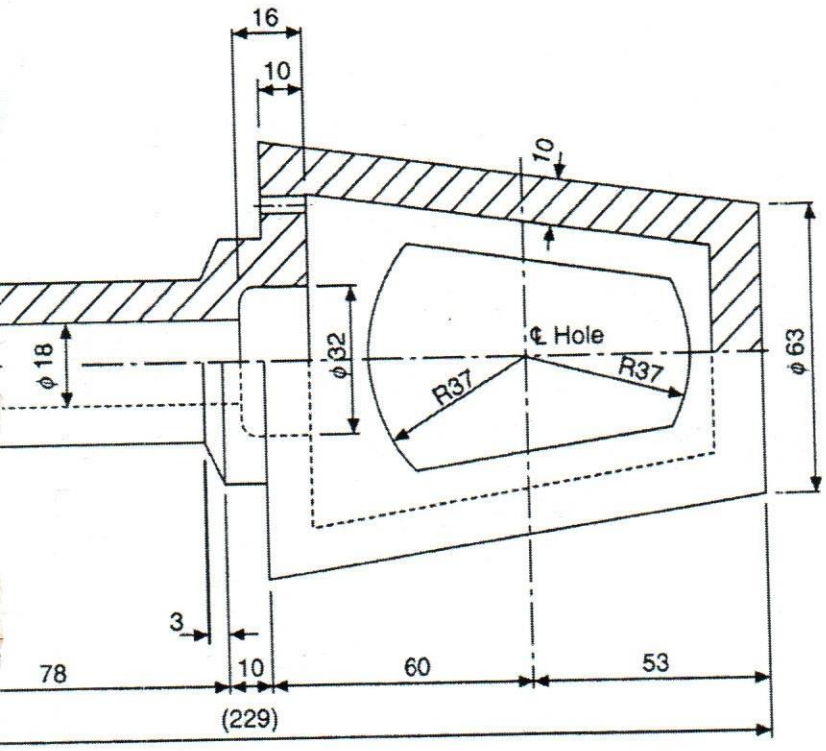


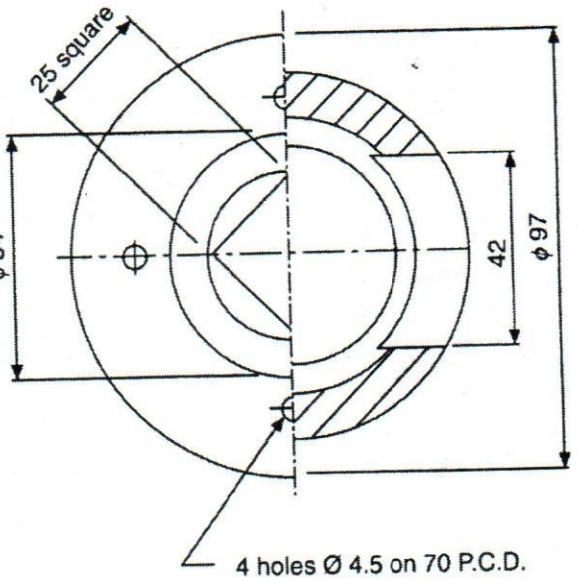




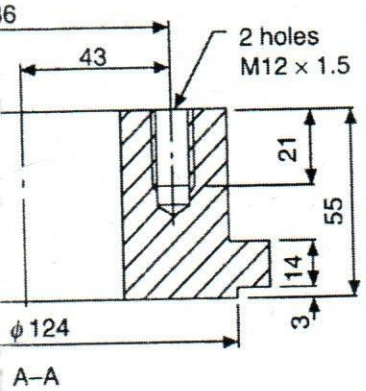


3 V

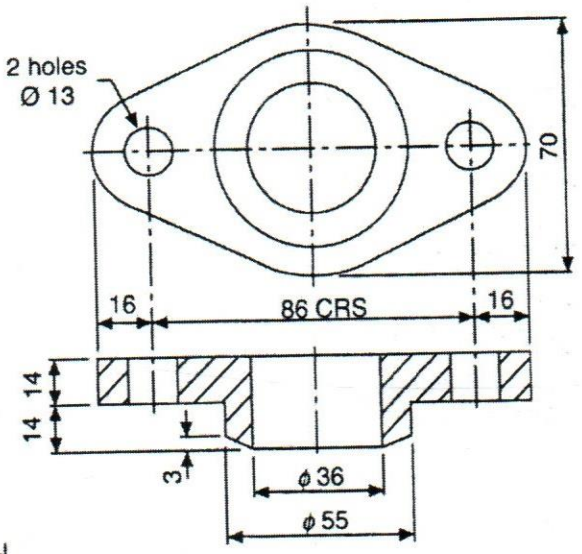




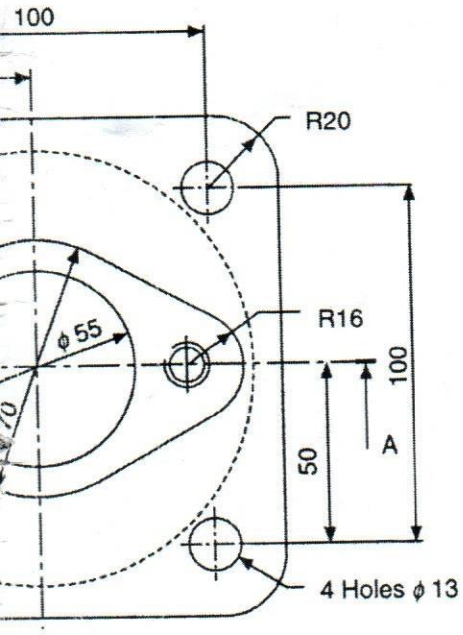
(2) Plug
- Monel Metal



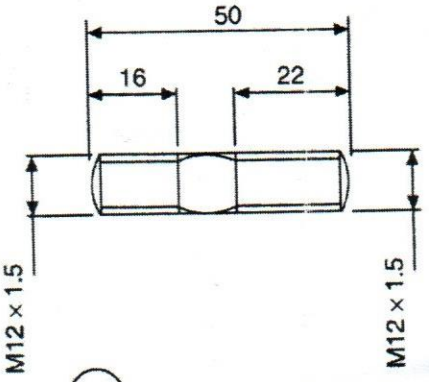
A–A



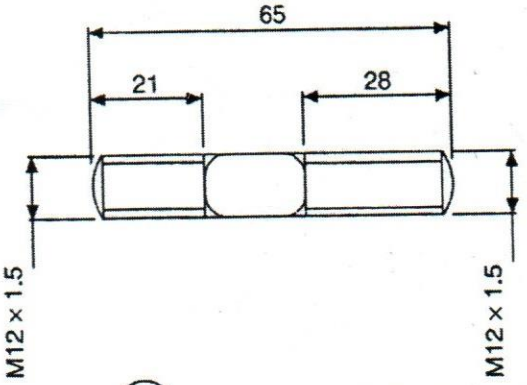
(4) Gland - Bronze



ve body cover - Cast Steel



(5) Cover stud - Mild steel



(6) Gland stud - Mild Steel

PLUG COCK
1ST ANGLE PROJECTION

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: 2018.01.03** **Pass marks: 50%**

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

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1. Risk Management is an essential requirement under International Safety Managements Code on board ships.
   a. What are the four (04) key processes of the Risk Management. (04 Marks)
   b. Briefly explain the way those processes stated in above "a", could be used for carrying out bunkering operation of a ship safely. (12 Marks)

2. 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)

3. International Maritime Organization (IMO) is the main organization which governs the international maritime activities.
   a. Aid of suitable sketch show the structure of the organization. (05 Marks)
   b. i. Briefly explain the Assembly
      ii. What are the functions of the Council (06 Marks)
   c. What are the five (05) instruments that IMO uses to adopt the various legislations. (05 Marks)

4. 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 Survey & Certification system. (04 Marks)

5. Amendments has been carried out STCW convention in Manila year 2010.
   a. Briefly explain why it was required to amend the convention. (04 Marks)
   b. What are the most significant amendments which had been carried out to STCW in Manila year 2010. (06 Marks)
   c. What is the Rest Hours & Work Hours requirement for seafarers according to the new amendments to the STCW? (06 Marks)

6.
   a. Under the Load line convention for merchant ships, define 'Freeboard' and 'Reserve Buoyancy'. (03 Marks)
   b. What are the 04 types of ships defined by above convention? (04 Marks)
   c. Briefly explain one of above type. (03 Marks)
   d. List 04 items which comes under the Conditions of Assignment for assigning Load Line for a commercial vessel. (06 Marks)

7. International Ballast Water Management convention implemented to prevent the harm caused from seawater ballast carried on board ships to ecological balance of the sea.
   a. What are the essential documents to be carried on board ships to comply with the requirement of this convention? (04 Marks)
   b. State the validity period of the certificate issued to ship under this convention & the issuing authority of the certificate. (04 Marks)
   c. What are the two standards in Ballast Water Management convention to prevent possible harmful activities of invasive species. (08 Marks)

8. Emission of various gases from the ships are required control to protect the atmosphere.
   a. Explain the effect of "Green House Gasses" on global warming. (03 Marks)
   b. State five (05) gases comes under control of Marpol Annex VI. (05 Marks)
   c. What are the certificates & documents required to carry on board ships to comply with annex VI requirements. (06 Marks)
   d. What are the present limitations applicable for the Sulphur content of the fuel used on board ships. (02 Marks)

9. Polar Code has been in force since 01st January 2017.
   a. State 05 hazards identified for vessels operating in polar areas. (05 Marks)
   b. What are the ship categories define under this Code? (03 Marks)
   c. State 04 exemptions that could be granted for existing ships operating in polar areas under the Code? (04 Marks)
   d. What are the essential documents required to be carried on board ships which are subjected to control under this code. (04 Marks)

3. A furnace wall consists of ***125 mm*** wide refractory brick and ***125 mm*** wide insulating firebrick separated by an air gap. The outside wall is covered with ***12 mm*** thickness of plaster. The inner surface of the wall is at ***1100 ^{0}C*** and the room temperature is ***25 ^{0}C***. The heat transfer coefficient from the outside wall surface to the air in the room is ***17 W/m^{2}K***. The thermal conductivities of refractory brick, insulating firebrick and plaster are ***1.6, 0.3*** and ***1.4 W/mK***, respectively.

   a. Calculate

      i. The overall heat transfer coefficient (4 marks)

      ii. The rate of heat loss per unit area of wall surface (4 marks)

      iii. The temperature at each interface of the wall (8 marks)

   b. Sketch the temperature variation through the composite wall and the surrounding. (4 marks)

4. In an air-standard Otto cycle, air initially at a temperature of ***300K*** and a pressure of ***1bar*** is compressed isentropically through a compression (volume) ratio of ***6***. A quantity of heat of ***1400kJ/kg*** is then added at constant volume. This is followed by isentropic expansion to the original volume. Heat rejection at constant volume returns the air to its original state. Find

   a. The pressure and temperature at the end of compression (4 marks)
   b. The maximum temperature of the cycle (2 marks)
   c. Work done per kg of air (6 marks)
   d. The efficiency of the cycle (6 marks)
   e. The Carnot efficiency within the same temperature limits (2 marks)

5. The volume compression ratio of a diesel cycle is ***14:1*** and constant pressure combustion occupies ***5%*** of the stroke. The pressure and temperature at the start of compression are ***1 bar*** and ***49°C***.Determine:

   a. The pressures and temperature at the other three points of the cycle (9 marks)

   b. The cycle efficiency (6 marks)

   c. The mean effective pressure (5 marks)

6. In a refrigeration plant, refrigerant "Ammonia" leaves the evaporator as dry saturated vapour at ***-6^0 C***. Then, compressed to a pressure of ***12.37 bar*** with ***50 ^{0}C*** superheat. It is cooled and condensed to a saturated liquid at the condenser under constant pressure. Then, it passes through a throttle valve and returns to the evaporator. The mass flow rate of the refrigerant is ***0.45 kg/min***.

   a. Draw the ***T-S*** and ***P-H*** diagram for the cycle (4 marks)

   b. Determine

      i. The condition of the refrigerant after the expansion in throttling valve (4 marks)

ii. The compression power (4 marks)

iii. Refrigerant effect power (4 marks)

iv. Coefficient of performance (4 marks)

7. Steam is the working fluid in an ideal Rankine cycle operating steam plant. The steam at ***8.0 MPa*** and ***425 ^0C*** enters the turbine and saturated liquid exits the condenser at a pressure of ***0.08 MPa***. The net power output of the cycle is ***300 MW***.

   a. Determine

      i. Condition of the steam after the expansion in the turbine (3 marks)

      ii. The mass flow rate of steam in kg/h. (3 marks)

      iii. The Rankine efficiency of the cycle (3 marks)

      iv. The rate of heat transfer from condensing steam as it passes through the condenser in kW (3 marks)

   b. Draw the ***TS*** diagram (4 marks)

   c. Determine the mass of coal burn in kg/h if the boiler thermal efficiency is ***69 %*** and the calorific value of the coal used is ***32.7 MJ/kg*** (4 marks)

8. Air is compressed in a single stage reciprocating compressor from ***1 bar***, ***8000 cm^3*** and ***25 ^0C*** at the beginning of the stroke to ***37 bar*** at the end of the stroke. After cooler has been introduced to drop the temperature to initial value after the compression. If the clearance volume is ***300 cm^3*** and the compression and expansion follows the index ***1.3***,

   a. draw the ***PV diagram*** of the air compressor stating the volume change in each cardinal point (5 marks)

   b. Compute

      i. The compression work done per cycle (5 marks)

      ii. The heat loss in the after cooler (5 marks)

      iii. volumetric efficiency of the compressor (5 marks)

9. A four-cylinder, four stroke oil engine ***90 cm*** in diameter and ***125 cm*** in stroke develops a torque of ***148 kNm*** at ***140 rpm***. The oil consumption is ***3.859 kg/min*** and its calorific value is ***42 MJ/kg***. If the mechanical efficiency of the engine is ***75.2 %***, find

   a. The brake power, indicated power, indicated mean effective pressure and fuel power (12 marks)

   b. Brake thermal efficiency and indicated thermal efficiency (4 marks)

   c. The brake specific fuel consumption and indicated specific fuel consumption (4 marks)

17

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: 2017.12.29** **Pass marks: 50%**

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

Part A

1. a) An alternating current $i(t)$ is given by $i(t) = 141.4 \sin 314t$, Find (10 marks)

   i. The maximum current ii. Frequency iii. periodic time

   iv. The instantaneous current value when t is 3ms. v. r.m.s. current

   b) An A.C. circuit consists of a pure resistance of 10 Ω and is connected across an a.c. supply. If instantaneous current of circuit is $i(t) = 141.4 \sin 314t$.

   i. Calculate power consumption. (05 marks)

   ii. Derive equation of instantaneous voltage across resister. (05 marks)

2. a) Compare resistance and reactance with regard to electrical circuits (06 marks)

   b) A 15Ω resistor, 50mH inductor and 200μF capacitor are connected in series to form a complex load. The load is connected to 220V, 50Hz sinusoidal power supply.

   i. Calculate the impedance of the load (07 marks)

   ii. Calculate the load current and plot the current and voltage waveforms on the same graph, indicating all the important figures. (07 marks)

3. a) Draw the equivalent circuit of a separately excited DC motor and label all key parameters. (06 marks)

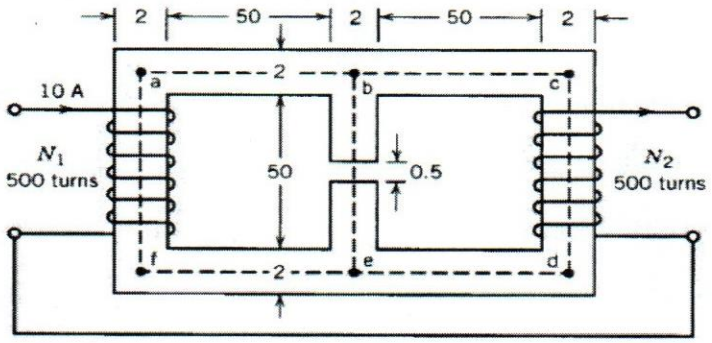
   b) A 230V shunt motor takes 5A at no load. The resistances of the armature and field circuit are 0.25 Ω and 115 Ω respectively. If the motor is loaded so as to carry 40A, determine

   i. iron and friction losses ii. Efficiency (14 marks)

4. a) State the relationship among parameters of a magnetic circuit corresponding to the Ohm's law in electric circuits. (06 marks)

   b) In the magnetic circuit, the relative permeability of the ferromagnetic material is 1200. Neglect magnetic leakage and fringing. All dimensions are in centimeters and the magnetic material has a square cross sectional area. Determine

i. the flux in the air gap (04 marks)
ii. flux density in the air gap (05 marks)
ii. magnetic flux intensity in the air gap (05 marks)



$(\mu_0 = 4\pi \times 10^{-7})$

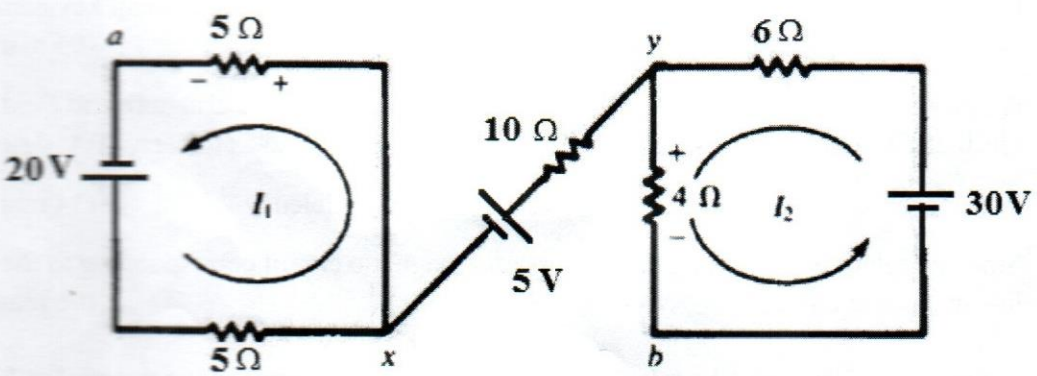
5. a) i. Express Lenz's law (03 marks)
ii. Define self-inductance (03 marks)

b) An air-cored solenoid having a diameter of 4 cm and a length of 60 cm is wound with 4000 turns. If a current of 5A flows in the solenoid, calculate
i. the inductance (05 marks)
ii. Energy stored in joules (05 marks)
iii. the e.m.f. induced in the coil when the current is uniformly reduced to zero in 10ms. (04 marks)

6. a) A length of wire has a resistance of 4.5 Ω. Find the resistance of another wire of the same material two times long and twice the cross-sectional area. (06 marks)

b) State Kirchhoff's laws for electrical circuits. (04 marks)

c) Find the current I_1, I_2 and voltage Vab in the following network. (10 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

NAVAL ARCHITECTURE AND SHIP CONSTRUCTION

- **TIME ALLOWED - THREE HOURS**
- **Answer ANY FOUR questions from Part A and ANY TWO questions from Part B**
- **Date: 2017.12.27** **Pass marks: 50%**

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

Part A: NAVAL ARCHITECTURE

1.

a. Define followings

i. Tonnes Per Centimeter (TPC) (03 marks)

ii. Water Plane Area Coefficient (C_w) (02 marks)

b. Half ordinates of a water plane of 120m long ship floating at 10m summer draft is as follows.

Station	FP	1/2	1	2	3	4	5	5 1/2	AP
½ Ord	0.1	7.5	10	12	12.3	11.4	8	5.2	1.0

Find

i. The Water plane (A_w) area at that draft (05 marks)

ii. TPC at summer draft in salt water (03 marks)

iii. FWA (03 marks)

2. A ship of 18000 tonne displacement has its longitudinal center of gravity 1.5 m aft of mid-ship.

Following operations are now carried out while the ship is in a port.

Discharged 2500 t Cargo @ 8.9m LCG forward of midship

Loaded 30 t stores @ 40.0m LCG forward of midship

Loaded 500 t Fuel oil @ 10.0m LCG aft of midship

Loaded 700 t Cargo @ 15m forward of midship

a. Calculate the new longitudinal location of the center of gravity of the ship on completion of above operations in port. (08 marks)

b. If vessel consumed 200 t of fuel during sea passage to next port, calculate the LCG of the vessel on arrival. (08 marks)

3.

a. Define the term "Metacentric height (GM)" (04 marks)

b. Initial KG of a ship having 5468 MT Light Displacement is 7.6m.

Load 750 MT VCG 6.2m

Load 175 MT VCG 8.3m

De- ballast 246MT VCG 1.6m

Received IFO 360 MT VCG 5.2m

Below is the hydrostatic particulars:

T(Draft)	Δ (Displacement)	KM	TPC
6.50	6410	8.15	19.8
6.60	6604	8.20	21.5

Find the Final GM of the vessel. (12 marks)

4. Lightship displacement of a 120m long vessel is 1850 tonnes and LCG is 5.40 m aft of mid-ship.

The following items are now loaded:

Cargo 2900 tonne, LCG 6.20 m forward of mid-ship

Fuel 120 tonne, LCG 32.50 m aft of mid-ship

Water 25 tonne, 40.25 m aft of mid-ship

Stores 5 tonne, 50.0 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
5.0	4925	51.14	1.20 F	1.40 A

Calculate the final end drafts of the vessel. (16 Marks)

Part B

7. a) Explain the advantages and disadvantages of an insulated neutral distribution system. (05 marks)

   b) Explain the advantages and disadvantages of an earthed neutral distribution system. (05 marks)

   c) Explain how high voltage systems are earthed in oil tankers. (05 marks)

   d) Explain, using a circuit diagram, how earth fault monitoring is applied to 3-ph, 440V power suppl utilizing 3 lamps and 3 resistors. (05 marks)

8. a) List the routine and emergency services normally supplied by batteries in shipboard practices. (10Marks).

   b) Explain the dangers which may exist in Battery room and explain how they are overcome. (05 Marks)

   c) State the ranges of Voltage and specific gravity Lead acid and alkaline batteries can be used. (05 Marks).

9. a) List the essential services which are supplied from Emergency generator. (06 marks)

   b) What are the type of instrument transformers found on board ship? (04 marks)

   c) What are safety precautions to be taken before removing ammeter from circuit (04 marks)

   d) Draw a system diagram of a typical distribution system showing Main Generators and Emergency Generator to their respective bus bars and how they are interconnected. (06 Marks)

5.

a. What are the two main components of resistance to be overcome by a ship when moving through the water. (03 marks)

b. List the factors effecting the magnitude of each of above component. (03 marks)

c. Wetted surface area of a 4.0 m long model ship is 5.8 m^2. The force required to tow the modal at 3.0 knots in freshwater model testing tank is 33.0 N. The length of the vessel expected build from this model is 120m. Calculate the effective power required for the ship to operate at its corresponding speed, allowing 15% for the "Ship correlation Factor" (SCF). (10 marks)

$f = 0.417 + \frac{0.773}{L+2.862}$ where L is the length in m.

$R_f = f S V^n$ (N) where S in m^2 & V in Knots, n = 1.825, $S \propto L^2$ for similar figures

Density of Seawater = 1.025 t/m^3

6.

a. Define following terms with respect to marine propellers;

i. Pitch (02 marks)

ii. Wake Speed (02 marks)

iii. Apparent Slip (02 marks)

iv. Real Slip (02 marks)

b. The Pitch Ratio (p) of the propeller of a 12,000 tonne displacement, 120m long & 17.2 m beam ship is 0.8 and the propeller diameter (D) is 5.6 m. At 7.5m loaded draft, the main engine operates at MCR to rotate propeller at 120 RPM. The wake fraction w = $0.5C_b - 0.05$ & the real slip is 35 %.

Calculate;

i. Speed of advance (04 marks)

ii. The speed of the ship (02 marks)

iii. Apparent slip (02 marks)

Part B: SHIP CONSTRUCTION

7.

a. Sketch a transverse section of a double bottom tank in way of a solid floor labeling the major structural components. (07 marks)

b. Explain the purpose of double bottom tanks in ship construction. (02 marks)

c. What are the important structural areas/components required to check when inspecting a ballast tank. (05marks)

d. Indicate a method used for testing a ballast tank for water tightness. (02 marks)

8.

a. Explain the terms below;

i. welding (03 marks)

ii. brazing and (02 marks)

iii. soldering (01 marks)

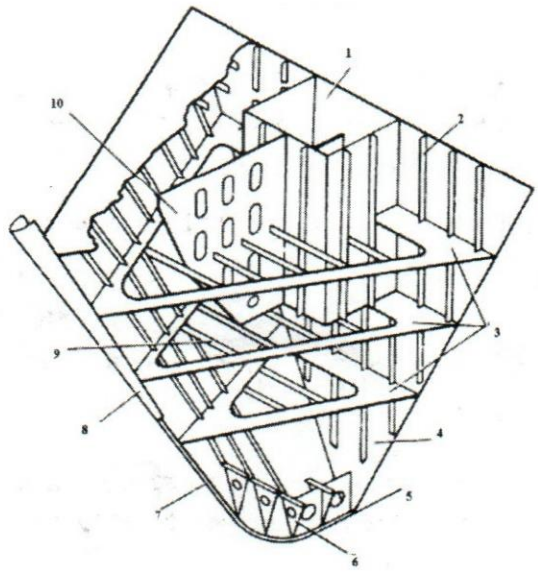
your answer should contain the principle method of joining, application of above joints and advantages and disadvantages.

b. Discuss with the aid of simple sketches type of joints used in welding. (08 marks)

c. How do you ensure the weld joint qualities are similar to the parent metal used for the welding? (02 marks)

9.

a. Identify the components numbered from 1 to 10 in a fore end structure of a ship shown below. (04 marks)



b. Explain the function/purpose of any six components stated in above part "**a** " (12 marks)

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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 SIX questions only**
- **Date: 2017.12.28**

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 – 1100 kgm^{-3}

1.

1.1. State Energy Conservation Law (ECL). Prove the Law using an example motion. (08 marks)

1.2. Delivery trucks that operate by m aking use of energy stored in a rotating flywheel have been used in Europe. The trucks are charged by using an electric motor to get the flywheel up to its top speed of 624 rad/s. One such fly wheel is a solid, homogeneous cylinder with a mass of 512 kg and a radius of 97.6 cm. (a) What is the kinetic energy of the flywheel after charging? (b) If the truck operates with an average power requirement of 8.13 kW, for how many minutes can it operate between charging's? (12 marks)

2.

2.1. Show that torque required at a hoist drum(of mass 'M' and radius of gyration 'k') to raise a mass 'm' with upward acceleration 'a' and against friction couple of 'τ_f' is given by, (06 marks)

$$Mk^2\frac{a}{r} + mr(g + a) + \tau_f$$

2.2. Hence or otherwise determine, the torque required at the drum and power required after accelerating for 5 seconds from rest, for a hoist drum of moment of inertia 90 kgm^2 used to raise a lift of 1.5 tones with an angular acceleration 4 $rads^{-1}$. Take drum diameter 1.2m. Assume the cable is light. (08 marks)

2.3. If the drum driven by an electric motor, determine also the work-done by motor if the cable has 5m length freely hanging and weighing 500 N without lift. (06 marks)

3.

3.1.Differentiate the terms Absolute velocity, mean velocity and average velocity.

(06 Marks)

3.2.A particle is dropped from the top of a tower 100m high. Another particle is projected upwards at the same time from the foot of the tower, and meets the first particle at a height of 30m. Find the velocity with which the second particle is projected upwards.

(14 marks)

4.

4.1.

a. Define Simple Harmonic Motion.
b. Derive an expression for frequency of vibration of a spring. (08 marks)

4.2.A helical spring, negligible mass and which is found to extend 0.25 mm under a mass of 1.5kg, is made to support a mass of 60 kg. The spring and the mass system is displaced vertically through 12.5 mm and released. Determine the frequency of natural vibration of the system. Find also the velocity of mass, when it is 5 mm below its rest position.

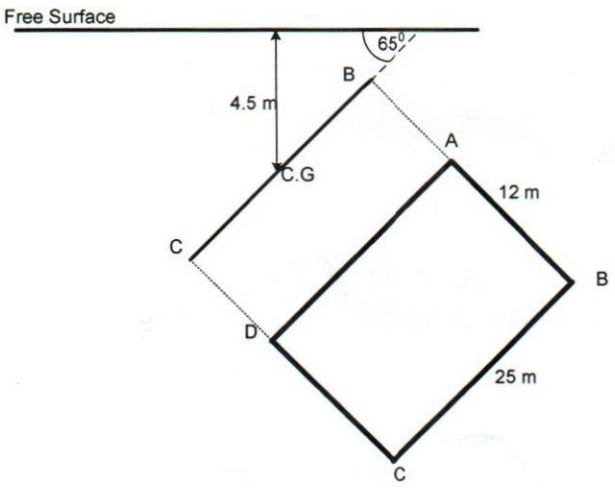
(12 marks)

5. Multi disc clutch has five discs on the driving shaft and four discs on the driven shaft and makes total of eight contact surfaces. The outside diameter of the contact surface is 340 mm and inside diameter of that surface is 220 mm. Assuming uniform pressure condition, find the maximum axial thrust acting on the clutch, when it is running at 1575 r.p.m and transmitting 35kW. Take coefficient of friction as 0.3 (20 marks)

6.

6.1.Define term 'Centre of pressure' and 'total pressure force'. (05 marks)

6.2.A rectangular plate of ABCD is immersed on a liquid having relative density of 0.85 as shown on figure. Find the total pressure force acting on one side of the plate and position of center of pressure. (15 marks)



7.

7.1.Define terms used in Torsional equation. (05 marks)

7.2.A solid shaft of 80 mm diameter is to be replaced by a hollow shaft of external diameter 100mm. Determine the internal diameter of the hollow shaft if the same power is to be transmitted by both the shafts at the same angular velocity and shear stress.

(15 Marks)

8. One end of a uniform beam with weight of W, is touched to the vertical wall and other end is touched to the horizontal. Both surfaces are rough with coefficient of friction equal to μ and μ^1 respectively. If the beam is about to slide, show that the angle created with horizontal is, $\tan^{-1}\left(\frac{1-\mu\mu^1}{2\mu}\right)$. Also determine the reaction at vertical wall. (20 marks)

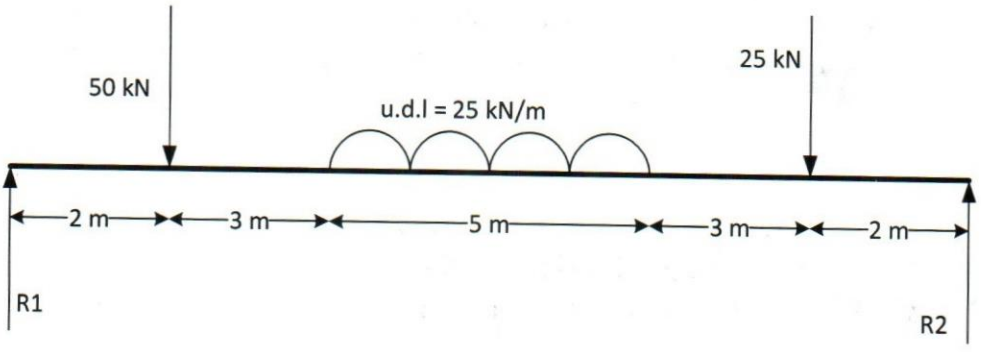
9.

Figure shows the loading of a simply supported beam with u.d.l and point loads. Determine,

9.1.Two reactions, R_1 and R_2 (05 marks)

9.2.Bending and shear force diagrams (10 marks)

9.3.Maximum bending moment and location (05 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

ENGINEERING DRAWING

- **Time Allowed - Four Hours**
- **Date: 2017.09.06** **Pass Mark 50%**

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

Figure shows details of a **Diaphragm Regulator**.

Draw the following views, using **third angle projection**, of the **Diaphragm Regulator** with the parts assembled in their correct relative positions. Select a suitable scale.

(a) Sectional elevation, the plane of the section and the direction of the required view being shown at **EE**.

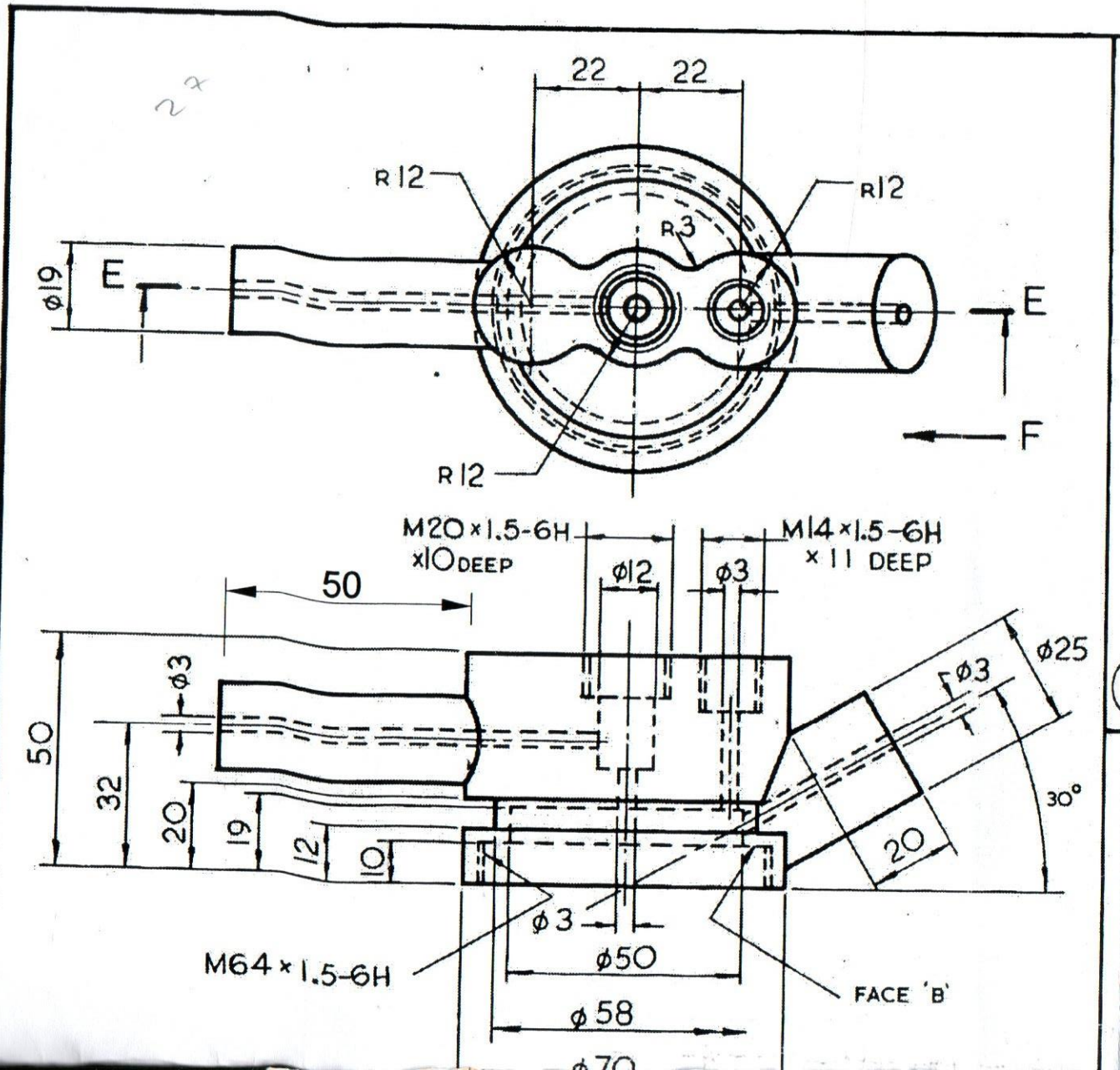
(b) Elevation looking in the direction of the arrow **F**.

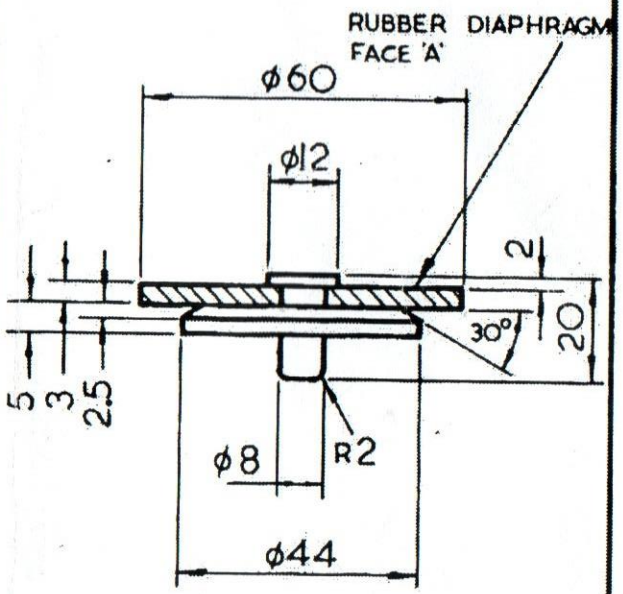
Suitable dimensions should be estimated where not provided. Hidden detail is not required in any view.

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

Marking System

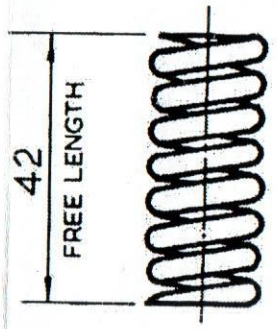
(i). Assembling accuracy of view (a)	(45 marks)
(ii). Assembling accuracy of view (b)	(30 marks)
(iii). Optimization of space	(05 marks)
(iv). Dimensioning	(05 marks)
(v). List of materials of parts	(05 marks)
(vi).Title block, projection symbol, lettering	(05 marks)
(vii). Final appearance, neatness	(05 marks)





DIAPHRAGM ASSEMBLY
- RUBBER & BRASS
ONE REQUIRED

(2)



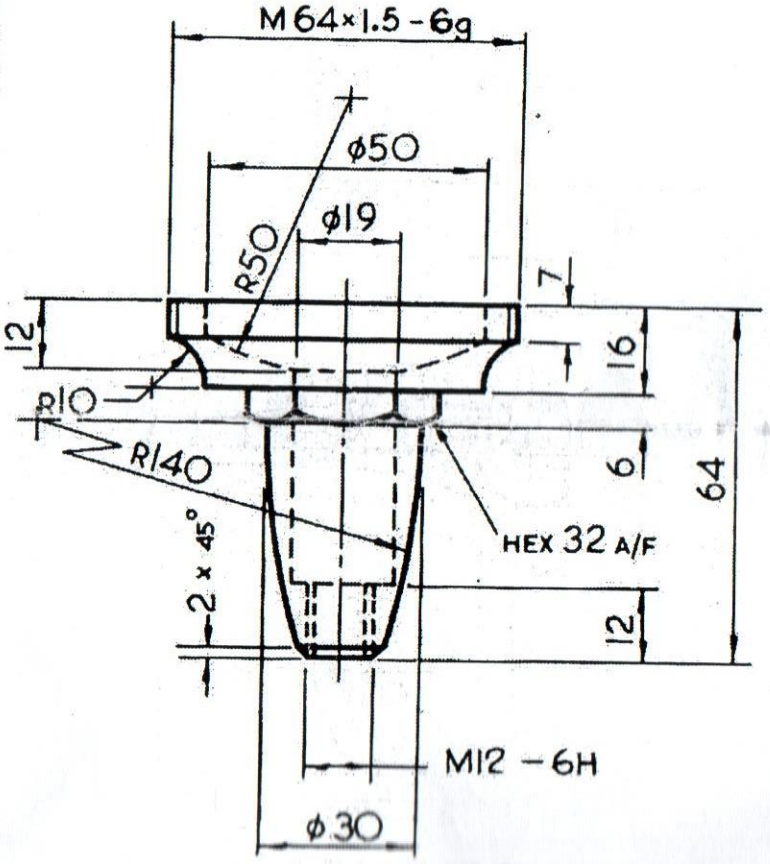
WIRE DIA = 3
COIL O/D = 18

7 FULL COILS + $\frac{3}{4}$ TURN AT EACH END SET AND GROUND TO FORM

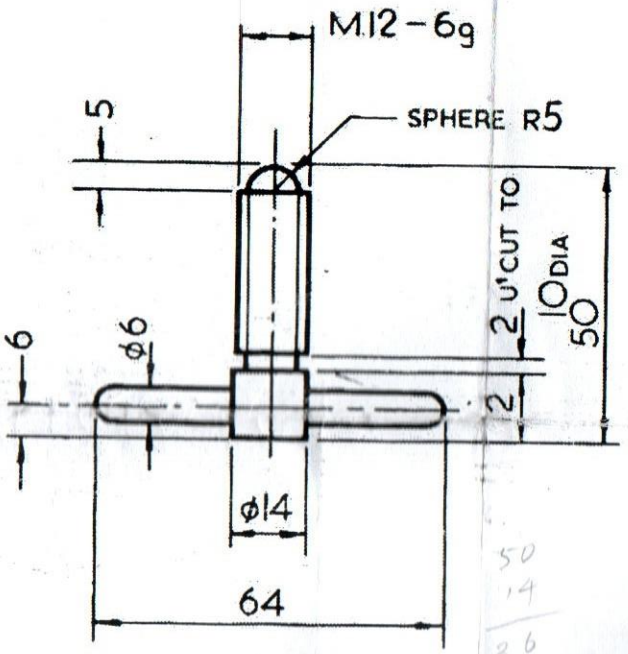
A FLAT SEAT

(1) BODY - *BRASS*
ONE REQUIRED

(4) SPRING - *STEEL*
ONE REQUIRED

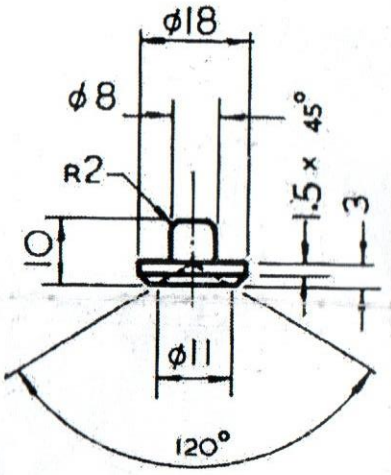


(3) COVER - *BRASS*
ONE REQUIRED



SCREW - *BRASS*
ONE REQUIRED

(6)



LOCATOR - BRASS
ONE REQUIRED

(5)

DIAPHRAGM REGULATOR

DATE
THIRD ANGLE PROJECTION
ALL DIMENSIONS IN MM

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MINISTRY OF PORTS AND SHIPPING

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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 **SIX (06)** Questions.*

Pass Mark 50%

- **Date: 2017.09.04**

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

1. Referring to Risk Management on board ships, briefly define following terms;
   a. Hazards (03 Marks)
   b. Risk. (03 Marks)
   c. Risk Assessment. (03 Marks)
   d. List 04 numbers of hazard involve with bunkering operation of a ship and briefly explain the control methods could be used to mitigate the risk from those hazards. (07 Marks)

2. United Nations Convention of the Law of Sea – III (UNCLOS-III) was came in to force on 16 November 1994 and established regulations for sharing ocean areas & its resources.
   a. Indicate the various sea areas define by the convention using a suitable sketch. (06 Marks)
   b. State four (04) international conventions which are currently in force to prevention of sea pollution by maritime activities. (04 Marks)
   c. State the name of the convention regulates the pollution of sea by dumping waste into sea. (02 Marks)
   d. Define terms "Dumping" & "Operational wastes" as stated in above convention. (04 Marks)

3. International Maritime Organization (IMO) was established in 1948.
   a. What are the primary objectives of establishing such an organization. (03 Marks)
   b. State five (05) main committees of IMO. (05 Marks)
   c. What are the five (05) instruments that IMO uses to adopt the various legislations. (05 Marks)
   d. Briefly describe one (01) of instruments stated above answer "c" (03 Marks)

4. Regarding the Ship Certification

a. State five (05) parties interested on ship certification. (05 Marks)

b. Name the two main categories of ship certificates. (01 Marks)

c. State Items/Areas covered by each category and state common items/areas common to both categories. (07 Marks)

d. State 03 advantages of Harmonized Survey & Certification system. (03 Marks)

5. STCW convention has been amended twice since the first introduction in 1978.

a. When was the latest amendments of this convention came in to force? (02 Marks)

b. Briefly explain why it was required to amend several times in the past. (04 Marks)

c. State most significant seven (07) amendments carried out to STCW during Manila 2010 convention. (07 Marks)

d. What is the Rest Hours requirement for seafarers according to the new amendments of the STCW. (03 Marks)

6.

a. Briefly explain the main factors urged for IMO to introducing International Safety Management Code (ISM Code) to maritime industry. (02 Marks)

b. Define terms "Non-Conformity" & "Major Non-Conformity". (04 Marks)

c. State five (05) deficiencies related to each deck & engine department which could lead for a non-conformity or a major non-conformity during an ISM audit on board ship. (10 Marks)

7.

a. State the main objectives of assigning Free Board for a ship. (03 Marks)

b. What are the types of ships falling under International Load Line Convention? (01 Marks)

c. List 06 items which comes under the Conditions of Assignment for assigning Load Line for a ship. (12 Marks)

8. International Ballast Water Management convention will come in to force soon.

a. State the date of above convention come in to force. (02 Marks)

b. What are the documents to be carried on board ships to comply with the requirement of this convention? (04 Marks)

c. State the validity period of the certificate issued to ship under this convention & the issuing authority of the certificate. (04 Marks)

d. What are the two standards for Ballast Water Management as per the BWM Convention. (06 Marks)

9. Emission of gases from the ships are controlled by the Marpol Annex VI.

a. State five (05) gases comes under control of this annex. (05 Marks)

b. What are the certificates & documents required to carry on board ship as per this annex requirements. (06 Marks)

c. State the validity period of the certificate(s) stated in answer (b). (01 Marks)

d. What are the present limitations applicable for the Sulphur content of the fuel used on board ships. (04 Marks)

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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 Any **SIX(06)** Questions.*
- **Date: 2017.09.01**

Pass Mark 50%

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

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

a. ***0.05 kg*** of steam at ***15 bar*** is contained in a rigid vessel of volume ***0.0076 m^3***. What is the temperature of steam? (4 marks)

b. If the vessel is cooled, at what temperature will the steam be just saturated? (4 Marks)

c. Cooling I continued until the pressure in the vessel is ***11 bar***. Calculate the final dryness fraction of the steam, and the heat rejected between the initial and final state. (12 marks)

2. A low grade fuel with ***68 %*** of ***Carbon (12)***, ***12 %*** of ***Hydrogen (1)***, ***3 %*** of ***Sulphur (32)***, ***6 %*** of ***Oxygen(16)*** and the remaining incombustible material. Estimate

   a. The high calorific value of the fuel (4 marks)

   b. The lower calorific value of the fuel (4 marks)

   c. The stoichiometric air/fuel ratio (4 marks)

   d. The composition of the exhaust gas on percentage mass basis. (8 marks)

   Take the calorific values of ***C, H*** and ***S 33.7, 144*** and ***9.3 MJ/kg*** respectively.

3. An electric hot-plate is maintained at a temperature of ***150 ^0C*** and used to boil water at ***120 ^0C***. The water is contained in an enameled cast-iron vessel of thickness ***30 mm*** and enamel thickness is ***0.8 mm***. The heat transfer coefficient of boiling water is ***2.5 $kW/m^2\ K$***, and thermal conductivities of cast iron and enamel are ***50*** and ***2.01 W/mK*** respectively.

a. Estimate

i. The overall heat transfer coefficient (6 marks)

ii. The rate of heat transfer per unit area (6 marks)

b. If the base of the vessel is not perfectly flat, a thin air film (***12 W/m^2 K***) is formed between the hot-plate and the base. Estimate the new rate of heat transfer per unit area (8 marks)

4.

a. Write an expression for the thermal efficiency of ***Diesel*** cycle (3 marks)

b. In an ideal air-standard Diesel cycle, the state before the compression process is ***0.95 bar, 290 K***. The isentropic compression ratio is ***16:1*** and isentropic expansion ratio ***6:1***. Find

i. The temperature and pressure after the compression (4 marks)

ii. The maximum temperature of the cycle (4 marks)

iii. The thermal efficiency of the cycle (4 marks)

iv. The mean effective pressure (5 marks)

5. An engine working on the dual combustion cycle has a constant volume pressure ratio of ***1.41***. The suction conditions are ***1 bar*** and ***27 ^{0}C***. If the compression ratio is ***13.5*** and the fuel cut off occurs at ***5%*** of the stroke,

a. Determine

i. The pressure and temperature at each cardinal points of the cycle (12 marks)

ii. Thermal efficiency (4 marks)

b. Compare the efficiency of the cycle with the efficiency of Carnot cycle operating under same temperatures (4 marks)

6. A steam plant operates between a boiler pressure of ***40 bar*** and a condenser pressure of ***0.05 bar***. Steam enters to the turbine at ***40 bar, 400 ^{0}C*** and an isentropic expansion of steam can be observed in the turbine. There is no sub cooling in the condenser and feed pump work can be neglected.

a. Sketch the ***T-S diagram*** for the cycle (4 marks)

b. Determine the dryness fraction of the steam after the expansion, work done by the turbine, heat transfer in the boiler and Rankine efficiency of the cycle (12 marks)

c. If the steam production of the boiler is ***7.3 kg of steam per kg of fuel*** burned, determine the thermal efficiency of the boiler. Calorific value of the oil fired in the boiler is ***37.2 MJ/kg***. (4 marks)

7. A single stage single acting reciprocating air compressor with ***0.3 m*** bore and ***0.4 m*** stroke runs at ***400 rpm***. The suction pressure is ***1 bar*** at ***300 K*** and the delivery pressure is ***5 bar***. The clearance volume is ***5 %*** of the stroke volume. Estimate
   a. The stroke and clearance volume per min (4 marks)
   b. The induced volume of air per min (4 marks)
   c. The volumetric efficiency (2 marks)
   d. The power required to run the compressor (4 marks)
   e. The change in internal energy during the compression in kW (6 marks)

8. A single cylinder, four stroke gas engine ***23 cm*** in diameter and ***40 cm*** in stroke runs at ***180 rpm***. The following readings are taken. The number of explosions is ***85 per min***, load on the brake wheel is ***810 N***, spring balance reading is ***100 N***, brake wheel diameter is ***152 cm***, the indicated diagram length and area are ***27 mm*** and ***450 mm^2***, indicator calibration is ***31.8 kPa/mm***, gas used is ***7.2 m^3/h***, calorific value of the fuel is ***21.5 MJ/kg***. Estimate
   a. The mean effective pressure (2 marks)
   b. Indicated power (4 marks)
   c. Brake power (4 marks)
   d. Indicated and brake specific fuel consumption (4 marks)
   e. The mechanical, indicated and brake thermal efficiency (6 marks)

9. A vapour compression refrigeration system (***R -22***) of ***35 kW*** capacity (*refrigerating effect*) operates with a condensing temperature of ***35 ^{0}C*** and evaporating temperature of ***-10 ^{0}C***. The refrigerant leaves the evaporator as dry vapour and leaves the condenser as saturated liquid.
   a. Draw the T-S and P-H diagram for the cycle (4 marks)
   b. Estimate
      i. The condition of the refrigerant at the evaporator inlet (4 marks)
      ii. The mass flow rate of the refrigerant (4 marks)
      iii. Power required by the compressor (4 marks)
      iv. The Coefficient of Performance (4 marks)

P_s, (bar)	V_g, (m^3/kg)	t_s (^{0}C)	Enthalpy, kJ/kg		Entropy, kJ/kg K		Degree of superheat 30 ^{0}C	
			h_f	h_g	s_f	s_g	h	s
3.543	0.06534	-10	33.01	246.14	0.1324	0.9422	266.84	1.0188
9.099	0.02600	20	68.67	187.84	0.2590	0.8997	280.50	0.9786
13.548	0.01727	35	87.70	260.22	0.3210	0.8809	285.78	0.9708

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 Any **SIX (06)** Questions.*
- **Date: 2017.08.31** **Pass Mark 50%**

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

1.

a. Solve the simultaneous equations

$$3^{x+3} = 9^{2-y}$$

$$\left(\frac{1}{2}\right)^{y} = 8^{x-4}$$ (6 marks)

b. Show that $\log_a b.\log_b c.\log_c a = 1$.

Hence, estimate the value of $\log_5 32.\log_4 7.\log_{49} 125$ (8 marks)

c. Solve the equation, $7^{2x} - 7^{x+2} + 48 = 0$ (6 marks)

2.

a. Find the constants A, B and C such that:

$$2x^2 + 6x + 5 \equiv (Ax + B)^2 + C$$ (5 marks)

b. Determine the range of values of k for which the quadratic equation

$kx^2 + 6(k-2)x + 3(k+1) = 0$ has two different real roots (5 marks)

c. The difference between the roots of the equation $2px^2 - qx + r = 0$ is t. Show that $q^2 = 4p^2t^2 + 8pr$. (5 marks)

d. Find the solution sets of the inequality, $|x^2 - 2x| \leq x$ (5 marks)

3.

a. Express in the form $a+ib$, where $i^2=-1$ and find $(A)\ z^2$ $(B)\ \frac{1}{z}$ for following complex numbers.

i. $\sqrt{\frac{1-i}{1+i}}$ ii. $\frac{(2-3i)(1+i)}{(2-i)}$ (10 Marks)

b. Find the modulus and the argument of the complex number $\frac{3-i}{1+(1+i)^2}$.

(5 Marks)

c. Simplify $\left\{\left(2\angle\left(\frac{\pi}{2}\right)\right)^2\left(4\angle\left(\frac{\pi}{6}\right)\right)\right\}\Big/\left(3\angle\left(\frac{\pi}{4}\right)\right)^3$ (5 Marks)

Hint: $r\angle\theta \equiv r\,Cos\theta + i\,r\,Sin\theta$

4.

a. For two given matrices $A=\begin{pmatrix}1&2&3\\3&3&-1\\-1&1&3\end{pmatrix}$ and $B=\begin{pmatrix}1&-2&1\\-1&1&2\\1&-2&0\end{pmatrix}$, Show that $AB \neq BA$

(8 marks)

b. Given the matrix $A=\begin{pmatrix}-1&-2&-2\\2&1&-2\\2&-2&1\end{pmatrix}$ find the adjoint of A (8 marks)

c. Hence, Find the inverse of A (4 marks)

5.

a. Prove the following trigonometric identities

i. $Cos^4\theta - Sin^4\theta = Cos2\theta$ (4 marks)

ii. $2Cot2\theta = Cot\theta - Tan\theta$ (4 marks)

b. Find the general solutions

i. $\sqrt{3}Sin\theta - Cos\theta = \sqrt{2}$ (4 marks)

ii. $Tan\theta + Tan2\theta = 0$ (4 marks)

c. Find the value of $Tan\frac{\pi}{16}$ and $Tan\frac{\pi}{8}$ without using the trigonometric ratio tables.

(Hint: $Tan\frac{\pi}{4}=1$) (4 marks)

6.

a. Differentiate the following functions with respect to x

i. $y=\dfrac{x^2+1}{(3x+1)^2}$ (5 marks)

ii. $y=\dfrac{Sin\,x+Cos\,x}{Sin\,x-Cos\,x}$ (5 marks)

b. If $x=2Cos\,t+Cos\,2t$ and $y=2Sin\,t+Sin\,2t$ and $Cos\dfrac{t}{2}\neq 0$, $Sin\dfrac{3t}{2}\neq 0$ show that $\dfrac{dy}{dx}=-Cot\dfrac{3t}{2}$ (5 marks)

c. If $y=\sin\sqrt{x}$, show that $4x\dfrac{d^2y}{dx^2}+2\dfrac{dy}{dx}+y=0$ (5 marks)

7.

a. Find all the real singular points of the function, $y=\dfrac{x^2}{1+x^3}$ (4 marks)

b. Estimate $\lim_{x\to\pm\infty}\dfrac{x^2}{1+x^3}$ (4 marks)

c. Determine the stationary points of the function, $y=\dfrac{x^2}{1+x^3}$ and their nature (8 marks)

d. Hence, plot the function $y=\dfrac{x^2}{1+x^3}$ (4 marks)

8.

a. Evaluate

i. $\int xsindx$

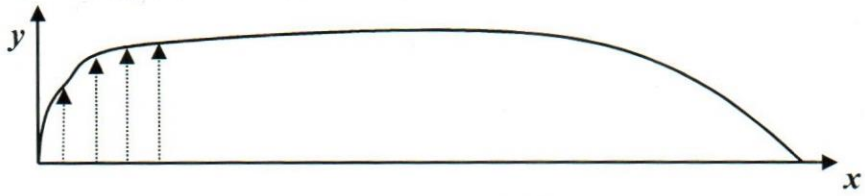
ii. $\int 5log_e xdx$

iii. $\int 2xe^{2x}dx$ (9 marks)

b. Find the area of the region R bounded by $y=x^2$, $x=-1$ and $x=-3$. (6 marks)

c. If R is rotated around x axis find the volume of the solid generated. (5 marks)

9. Figure represents a lamina made by coordinates given in the table below. Use the table and figure for the followings



x(m)	*0*	*0.5*	*1.0*	*1.5*	*2.0*	*2.5*	*3.0*	*3.5*	*4.0*	*4.5*	*5.0*	*5.5*	*6.0*	*6.5*	*7.0*	*7.5*	*8.0*
y(m)	*0*	*0.45*	*0.5*	*0.57*	*0.59*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.54*	*0.45*	*0.32*	*0.2*	*0.1*	*0*

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)

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 Four (04) Questions From* ***Part A****, and Two(2) Questions From* ***Part B.***
- **Date: 2017.08.30** **Pass Mark 50%**

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

Part A

1. a) i. Define magnetic field. (3 marks)

ii. Draw the pattern of the magnetic field produced by electric current through a straight wire and through a wire coil. (3 marks)

b) In the magnetic circuit detailed in Figure 1 with all dimensions in mm, calculate the required current to be passed in the coil having 200 turns in order to establish a flux of 1.28 mWb in the air gap. Neglect fringing effect and leakage flux. The B-H curve of the material is given in Figure 2. Permeability of air may be taken as $\mu_o = 4\pi \times 10^{-7}\ H/m$.

(10 marks)

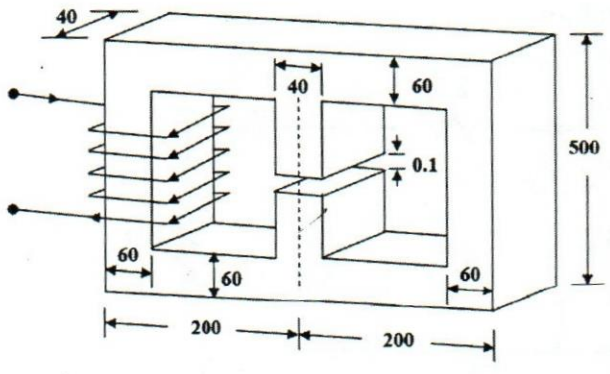


Figure 1

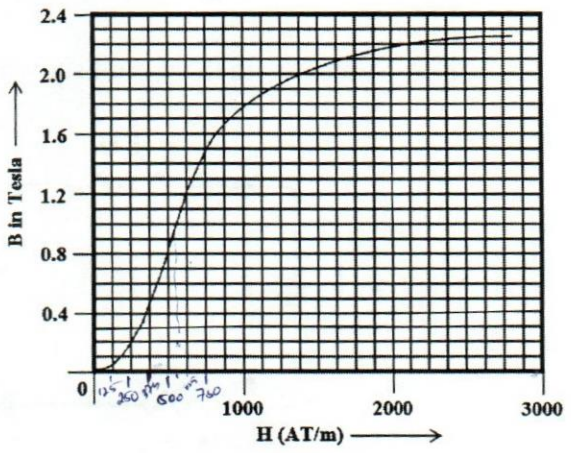
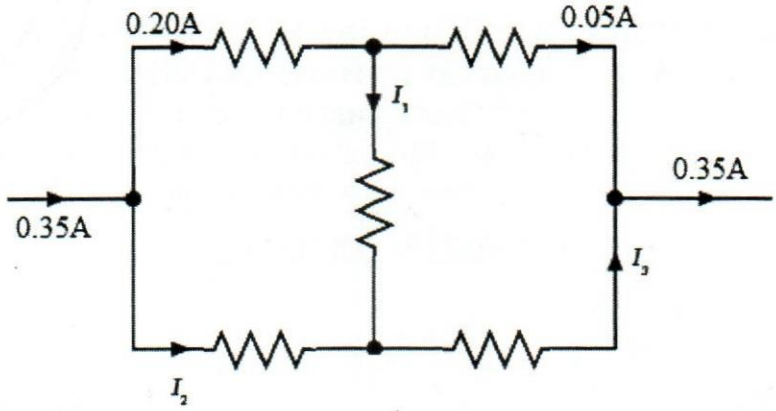


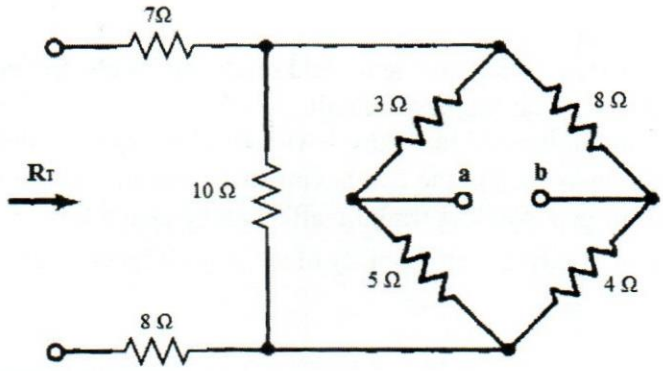
Figure 2

2. a) State Kirchhoff's laws. (3 marks)

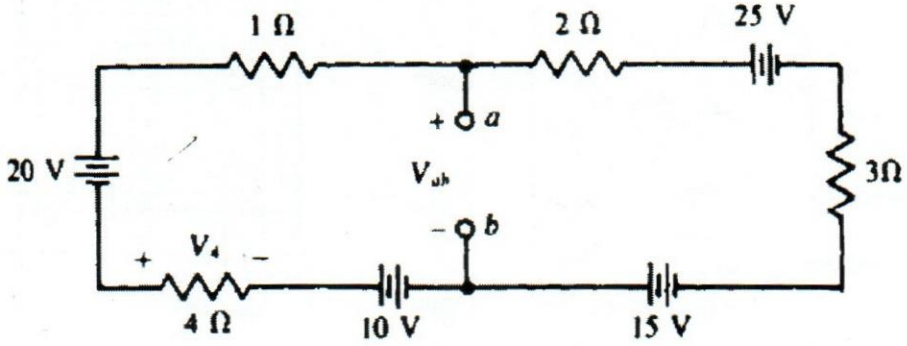
b) Determine the currents I_1, I_2 and I_3 in the circuit below. (3 marks)



c) i. In the circuit shown in figure, find R_T with terminals a and b (A) open-circuited and (B) short-circuited. (5 marks)



ii. Find V_{ab} in the circuit shown in figure. (5 marks)



3. a) Define reactance and impedance in A.C circuits

b) A series RLC circuit with $L = 160\ mH$, $C = 100\ \mu F$ and $R = 40.0\ \Omega$ is connected to a sinusoidal voltage $V(t) = 40 \sin \omega t$ with $\omega = 200\ rad/s$.

i. What is the impedance of the circuit? (4 marks)

ii. Let the current at any instant in the circuit be $I(t) = I_o \sin(\omega t - \phi)$. Find I_o (4 marks)

iii. What is the phase ϕ? (4 marks)

c) Find the resonant frequency. (4 marks)

4. a) Define inductance and express equations of equivalent inductance in series-adding and series-opposing inductors networks. (4 marks)

b) Two identical coils, when connected in series, have total inductance of 12H and 4H depending upon their method of connection. Find

i. self-inductance of the coils (2 marks)

ii. mutual inductance between the coils (2 marks)

c) A wooden toroid of mean diameter 400 mm and cross-sectional area 400 mm^2 is uniformly wound with a coil of 1000 turns which carries a current of 2A.

Determine i. self-inductance of a coil (4 marks)

ii. the e.m.f. induced in the coil when the current is uniformly reduced to zero in 10ms. (4 marks)

5. a) What are the difference between wave and lap armature windings. (3 marks)

b) Briefly explain power conversion stages in D.C. Generator with power losses. (3 marks)

c) A 75 kW shunt generator is operated at 230V. The iron losses and mechanical losses are 1810 W and shunt field circuit draws 5.35A. The armature circuit has a resistance of 0.035 Ω and brushes voltage drop is 2.2V. Calculate

i. Power loss of brushes and total power losses (4 marks)

ii. input of prime mover (4 marks)

iii. efficiency at rated load. (2 marks)

6. a) Explain the following (6 marks)

i. Potential transformer

ii. Current transformer

iii. Instrument transformer

b) A single-phase transformer is designed to operate at 2V per turn and turn ratio of 3:1. If the secondary winding is to supply load of 8kVA at 80V. Determine

i. the primary supply voltage (4 marks)

ii. number of turns on each winding (4 marks)

iii. the current in each winding. (2 marks)

Part B

7. With reference to the operation of Governors fitted to diesel alternators that are generally operate in parallel:

a) Explain what is meant by speed Droop, why an isochronous characteristic is undesirable. (5 marks)

b) Explain how actual power and reactive power are shared when AC machines are sharing load.. (5 marks)

c) Sketch a load / frequency diagram showing how two generators share the electrical Load. (6 marks)

8. a) What are the main types of A/C synchronous generators? (3 marks)

7346.47

b) Which type is the most suitable for slow speed to medium speed? (2 marks)
c) What are the protection devices attached to these generators? (5 marks)
d) Two 3-ph a.c generators are running in parallel under normal full load condition. Describe the probable sequence of events following a total loss of drive power to one generator. (6 marks)

9. With reference to the induction motors,
a) State four reasons for overheating. (4 marks)
b) State the consequences of Rotor Airgap being too large and too small. (4 marks)
c) Explain why the rotor of a 3 phase Induction motor cannot run at synchronous spee (4 marks)
d) State the precautions necessary prior to maintenance work being undertaken on a Induction Motor. (4 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

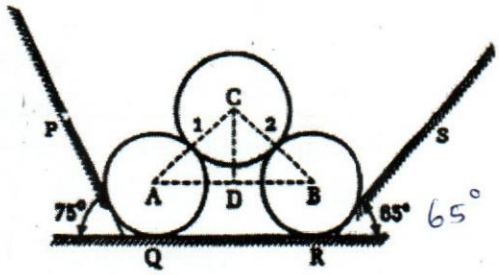
APPLIED MECHANICAL SCIENCE

- **Time Allowed - Three Hours**
- ***Answer Any SIX (06) Questions.***
- **Date: 2017.08.29** **Pass Mark 50%**

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

1. Three spheres A, B and C having their diameter 500mm, 500mm and 800 mm respectively are placed in a trench with smooth walls and floor as shown in B is 600 mm. The weights of the cylinders A,B and C are 4kN, 4 kN and 8 kN respectively. Determine the reactions P, Q, R and S.

(20 Marks)



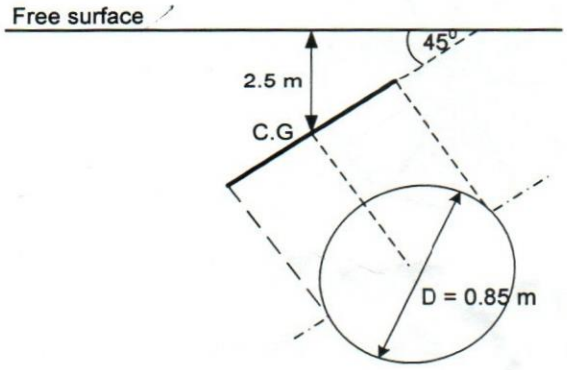
2.

2.1. Define Center of pressure of a submerge plate.

(05 marks)

2.2. Figure shows a circular plate with 0.85 m in diameter is immersed in water. The position of center of gravity is located at 2.5 m below the free surface. Find total pressure force acting on the plate and position of center of pressure.

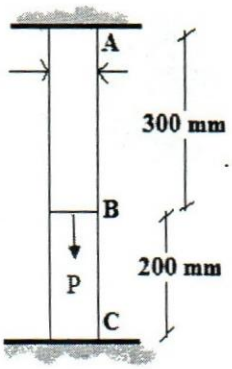
(15 marks)



3.

3.1. State Principle of superposition. (5 Marks)

3.2. A square bar of 20 mm side is held between two rigid planes and loaded by an axial force P equal to 450 kN as shown. Find the reactions at the ends A and C and the extension for the portion AB. Take E = 200 GPa. (15 Marks)

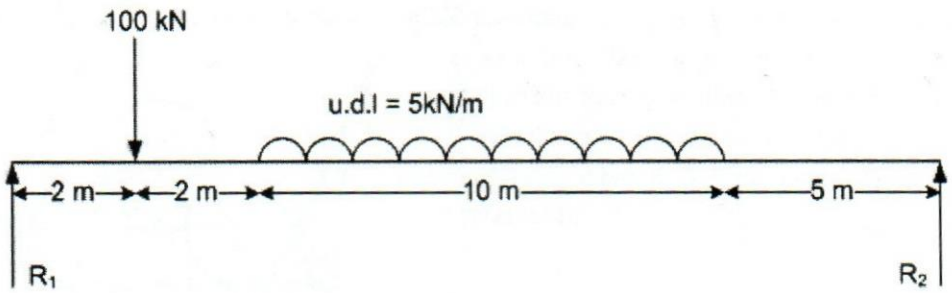


4. Simply supported beam with loading is given in following figure. Determine,

4.1. Bending moment diagram (8 marks)

4.2. Shear force diagram (8 marks)

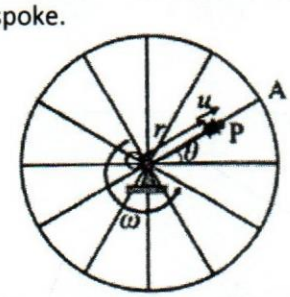
4.3. Maximum bending moment and point where it occur. (4 marks)



5.

5.1. Define Simple Harmonic motion. Derive its characteristic equation. (8 Marks)

5.2. An insect crawls at a constant speed 'u ms^{-1}' along the spoke of a bicycle wheel as shown, which is rotating with a constant angular velocity '$\omega\ rads^{-1}$'. Find the acceleration of insect in radial and perpendicular directions to the spoke. (12 Marks)



6. The acceleration, *f(t)* at time (t) of a particle is defined by following equation.

$$f(t) = t^4 + 3t^3 + 15t + 25$$

The velocity of a particle at t =1 sec, is 5.5 ms^{-1} and displacement is equal to 9 m. Find the displacement and velocity of a particle when t = 3 sec.

(20 marks)

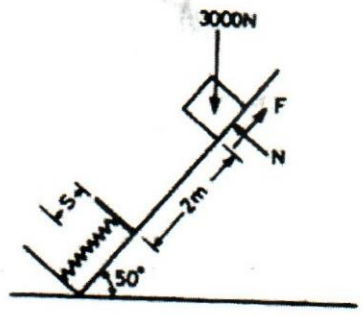
705.125 m

1057.87 m

7.

7.1. Differentiate Static and Dynamic friction coefficients. (4 Marks)

7.2. A 3000N block starting from rest as shown in figure slides down a 50^0 incline. After moving 2m it strikes a spring whose modulus is 20 N/mm. If the coefficient of friction between block and the incline is 0.2, determine the maximum deformation of the spring and maximum velocity of the block. (16 Marks)



8.

8.1 State conditions applied on "Uniform pressure" and "Uniform wear" in frictional clutches. (05 marks)

8.2 A single plate clutch with both sides effective has an outer and inner diameters are equal to 350 mm and 250 mm respectively. The maximum intensity of pressure at any point in the contact surface is not to exceed 0.15 N/mm^2 and axial thrust acting on the friction surface is equal to 1000 N. Determine the amount of power transmission at speed of 3000 r.p.m . (Take coefficient of friction as 0.55)

(15 Marks)

9.

9.1.

a. Define torsional Stress and strain. (4 Marks)

b. State two assumptions for shear stress in a circular shaft subjected to torsion. (4 Marks)

9.2. A hollow shaft is to transmit 200 kW at 80 rpm. If the shear stress is not to exceed 60 MPa and internal diameter is 0.6 of the external diameter, find diameters of the shaft. (12 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

NAVAL ARC & SHIP CONSTRUCTION

- **Time Allowed - Three Hours**
- **Attempt only (06) Questions**
- *Answer Four (04) Questions from* ***Part A****, and Two (02) Questions from* ***Part B.***

- **Date: 2017.08.28** **Pass Mark 50%**

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

Part A

1.

a. When relative densities of Fresh water & sea water are 1.0 & 1.025 respectively, prove that statutory fresh water allowance for a ship could be calculated from $FWA = \frac{\Delta}{40\,TPC}$, where Δ (displacement) & TPC are the corresponding values at summer load line draft. (6 marks)

b. The half ordinates at the summer draft of a 120m long ship are as follows.

Section	AP	½	1	1½	2	3	4	5	6	7	8	8½	9	9½	FP
½ Ordinates(m)	1.5	3.6	5.6	7.0	8	8.3	8.5	8.7	8.7	8.5	8.2	7.9	6.2	3.6	0

i. Calculate the area of the water plan at summer draft of the ship. (6 marks)
ii. Calculate the "Water Plan Area Coefficient" (C_w) of the ship. (2 marks)
iii. If the displacement of the vessel is 12000 tonne, find the distance between summer & fresh water load water lines of the ship. (2 marks)

2. A ship of 18000 tonne displacement has its longitudinal center of gravity 1.5 m aft of mid-ship. While the vessel is in port, 300 tonne of oil fuel in a forward fuel oil center tank located 80 m from the mid-ship transferred to similar size fuel oil center tank located 60 m aft of mid-ship & 500 tonne of new fuel bunkered into forward fuel oil tank. 200 tonnes of fuel has been consumed from the aft fuel oil tank during the passage to the next port.
Calculate the new longitudinal location of the center of gravity;
a. On completion of fuel transfer to aft fuel tank. (5 marks)
b. After completion of bunker operation. (5 marks)
c. On arrival of the new port after the sea passage. (6 marks)

3.

a. Regarding transvers statical stability of a ship, explain the terms "Stable", "Unstable" & "Neutral Equilibrium". (6 marks)

b. A vessel of 4500 tonnes light ship displacement and vertical center of gravity 4.5 m. At 12000 tonne displacement second moment of area of the water plain about the center line of the vessel is 80 x 10^3 m^4 & center of buoyancy is 3.5 m above the keel.
Following masses are now loaded.

1000 tonnes of ballast at VCG 1.25 m above the keel
3700 tonnes of cargo at VCG 7.20 m above the keel
2800 tonnes of cargo at VCG 9.25 m above the keel

Ballast water is stored in two identical DB tanks located Port & Starboard of the vessels longitudinal center line each having length X Breadth; 36 m X 12 m.

Calculate the Metacentric height (GM) of the vessel

i. If ballast tanks **are pressed** up to the tank top. (5 marks)
ii. If the ballast tanks **are not pressed** up to the tank top. (5 marks)

4. A ship 100 m long has a light displacement of 1250 tonnes and LCG 5.64 m aft of mid-ship.

The following items are now loaded:

Cargo 2500 tonne, LCG 5.20 m forward of mid-ship
Fuel 100 tonne, LCG 35.50 m aft of mid-ship
Water 20 tonne, 36.25 m aft of mid-ship
Stores 5 tonne, 38.0 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
5.0	3875	48.80	1.25 F	1.20 A

Calculate the final end drafts of the vessel. (16 marks)

5. Resistance exerted by the water when moves through the water at a speed could be divided into two main components as Frictional Resistance & Residuary Resistance.

a. List the factors effecting the magnitude of each of above component. (6 marks)

b. A 6 m mild steel model of a ship has a wetted surface area of 7 m^2 and when towed in fresh water at 03 knots, has a total resistance of 35 N. If the "Ship correlation Factor" (SCF) is 1.15, Calculate the effective power of a ship, 120 m long, at its corresponding speed. (10 marks)

$n = 1.825$, $f = 0.417 + \frac{0.773}{L+2.862}$ and $R_f = f S V^n$, density of seawater = 1.025

6.

a. Define following terms with respect to marine propellers;
   i. Pitch Ratio (2 marks)
   ii. Theoretical Speed (2 marks)
   iii. Apparent Slip (2 marks)
   iv. Real Slip (2 marks)

b. A propeller of 5.5 m diameter has a pitch ratio of 0.8. When main engine turns at MCR propeller rotates at 120 RPM. The wake fraction is found to be 0.32 & the real slip 35 %. Calculate;
   i. Speed of advance (4 marks)
   ii. The speed of the ship (2 marks)
   iii. Apparent slip (2 marks)

Part B

7.

a. Sketch FOUR types of rolled steel sections commonly employed to stiffen plating: (5 marks)

b. State were in ship's structure the rolled sections in (a) would be employed (5marks)

c. Sketch ONE alternative means used to stiffen large areas of plating (2 marks)

d. State the purpose of duct keel and state where it is located in a ship's structure. (4 marks)

8.

a. Sketch and identify the components used in a aft shaft seal of a oil lubricated stern tube bearing. *(8marks)*

b. Sketch and describe the forward shaft seal of a stern tube bearing. (6 marks)

c. What are the materials used sealing ring above. (1 mark)

d. In moderen construction what additional methods are utilized to prevent leakage of lub oil to sea (1 mark)

9.

a. Briefly explain the construction of un balanced rudder with an aid of a diagram. (8 marks)

b. Write a short note about controllable pitch propeller (6 marks)

c. With respect to marine propellers describe following terms using sketches where necessary:
   i. Pitch
   ii. Boss or hub
   iii. back (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

MARITIME LAW

- **TIME ALLOWED - THREE HOURS**
- **Answer any six questions**

Date: 2016.05.03

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

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1.

1.1 With reference to the convention on "Law of the Sea", Explain the followings;

a) Territorial Sea (02 Marks)
b) Exclusive Economic Zone (02 Marks)
c) Innocent Passage (02 Marks)

1.2

a). What are the five (05) important instruments of the International Maritime Organization. (05 Marks)

b). Briefly explain the any two (02) of above. (05 Marks)

2. With reference to the convention on STCW with particular emphasis on the 2010 Manila amendments;

a). Indicate in summary, the major changes made in the STCW 2010 amendments (08 Marks)
b). What are the new grades of certificate introduced by these amendments. (04 Marks)
c). State the Rest Hours requirement applicable for seafarers under this amendment. (04 Marks)

3. With regard to MARPOL annex I

a). What is mean by a Special Area (02 marks)
b). State 04 Special Areas listed under Marpol Annex I (02 Marks)
c). State the requirements to be met for pumping out machinery space bilges when the ships of 10000 GT and above are within special areas. (04 marks)
d). State the documents to be carried on board ship under Marpol Annex 1 (03 Marks)
e). State from where could you find the information/instructions & Procedures regarding prevent of pollutions of sea by oil from the ship. (02 Marks)
f). State four (04) operations required to be recorded in Oil Record book of Dry Cargo ship. (03 Marks)

4.

a) State the Certificate required to carry on board ship under Marpol Annex IV and the period of validity. (02 marks)
b) State the requirements to be fulfilled for discharging sewage from a ship? (06 marks)
c) What is mean by Operational Waste Under Marpol Annex V. (04 marks)
d) Name Four Operational waste stated under Marpol Annex V. (04 marks)

5. Emission of gases from the ships are controlled by Marpol Annex VI.

a). What is mean by Green House Effect. (02 Marks)
b). State four (04) gases of which the emissions are controlled under this annex. (04 Marks)
c). State the certificates required to carry on board ships under Marpol Annex VI. (02 Marks
d). State the information that could found in Engine Technical File. (04 Marks)
e). What are the objectives of having SEEMP on board ship. (04 Marks)

6.

a). State the objectives of the Ballast Water Convention. (04 Marks)
b). State when this convention is coming in to force. (02 Marks)
c). What are the limitations applicable for Ballast Water Exchange Processes. (06 Marks)
d). State four (04) technologies used for treating ballast water to meet required performance standard of the conventions. (04 Marks)

7. With regard to classification & Statutory surveys briefly explain;
[include; the purpose, frequency of surveys, the authority of issuing certificates as applicable in your answers]

(a) Docking Survey (DS) (04 Marks)
(b) Safety Equipment (SEQ) (04 Marks)
(c) Continuous Survey of Machinery (CSM) (04 Marks)
(d) Enhance Survey Program (ESP) (04 Marks)

8.

i.

a) What are the objective of the SOLAS Chapter IX -ISM Code. (02 Marks)
b) Define "Non-Conformity" & "Major Non-Conformity". (06 Marks)

ii.

a) What are the objectives of MLC -2006. (02 Marks)
b) State how many areas are essentially subjected to inspect by MLC inspectors on board a ship & name 05 areas of them. (06 Marks)

9.

a). State which ships are coming under LOADLINE Convention. (02 marks)
b). What is mean by Reserve Buoyancy. (04 marks)
c). What is the purpose of assigning a freeboard to a vessel. (04 marks)
e). State the issuing authority & the period of validity of the International Load Line certificate. (02 Marks)
f). What are the requirements to be fulfilled to maintain the validity of the above certificate. (04 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

Thermodynamics

- **Time Allowed - Three Hours**
- **Answer Any Six Questions**
- **Date: 2017.05.02** **Pass Mark 50%**

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

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

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1. The reversible expansion of a mass of ***0.06 kg*** of air in a cylinder is so controlled that the pressure changes according to the law $P = aV + b$, where ***a*** and ***b*** are constants. The initial and final pressures are ***15 bar*** and ***1.5 bar***,and the corresponding volumes are $0.003m^3$ and $0.03m^3$.

   a. Find the heat transferred during the process, stating clearly any assumptions made. Sketch the process on p-v diagram. (14 Marks)

   b. If the working fluid had been steam instead of air, would the results have been different? Give your reasons. (06 Marks)

2. In an air-standard cycle heat is supplied at constant volume to raise the temperature of the air from T_1 to T_2. The air then expands isentropically until its temperature falls to T_1 and after this, it is returned to its original state by a reversible isothermal compression process.

   a. Show that the cycle efficiency is; $\eta = 1 - \frac{T_1}{(T_2 - T_1)} \ln \frac{T_2}{T_1}$ (14 marks)

   b. Calculate the efficiency when the pressure rises from ***10*** to ***35 bar*** during the heat supply. (06 marks)

3. A spark ignition engine works an air standard ***Otto cycle*** that has a heat addition of ***1800 kJ/kg*** and a compression ratio of ***7***. The pressure and temperature at the beginning of the compression are ***1.03 bar*** and ***298 K***. Determine

   a. The maximum pressure and temperature of the cycle (5 marks)

   b. The specific work done (5 marks)

   c. Thermal efficiency of the cycle (5 marks)

   d. The mean effective pressure (5 marks)

4.

a. State the ***Fourier law in heat transfer***. (2 marks)

b. Describe the ***overall heat transfer coefficient*** (2 marks)

c. The walls of a cold chamber consists of an outer layer of wood of thickness ***30 mm*** and thermal conductivity ***0.18 W/m K***, and cork layer of thickness ***70 mm*** and thermal conductivity ***0.05 W/mK*** and inner layer of steel of thickness ***5 mm*** and thermal conductivity ***17.3 W/mK***. If the rate of heat transfer from and to each exposed surface is ***10 W/m^2K*** and the heat flow thorough the wall is ***24 W/m^2***, determine

i. The ***overall heat transfer coefficient*** including outer and inner fluid layers (4 marks)

ii. The ***temperature difference*** across the thickness of the wood, cork and steel (4 marks)

iii. The ***total temperature difference*** between the outside atmosphere and inside of room (4 marks)

iv. The ***temperature of the room*** when the external ambient temperature is ***20 ^0C*** (4 marks)

5. In an ideal ***Dual combustion cycle*** the volume compression ratio is ***12:1*** and the initial conditions of air are ***1.03 bar*** and ***303 K***. The maximum pressure of the cycle is ***41.4*** bar and the maximum temperature is ***1666 K***. Determine

i. Temperature and pressure at the end of compression (4 marks)

ii. The constant volume heat transfer (4 marks)

iii. The percentage of the fuel admission under constant pressure from the stroke (4 marks)

iv. The heat rejection under constant volume (4 marks)

v. The cycle efficiency (4 marks)

6. A single stage single acting air compressor takes in air at ***1 bar*** and ***27 ^0C*** and compresses it to ***10 bar*** and delivers at a rate of ***0.05 m^3/s***. If the compression and expansion follow the law ***$pV^{1.25}$ = constant***. The clearance volume is ***6%*** of the swept volume and the swept volume is ***0.0145 m^3***. Estimate

a. The temperature at the end of compression and the internal energy change of the air (5 marks)

b. The power required to drive the compressor (5 marks)

c. Speed of the compressor (5 marks)

d. Volumetric efficiency (5 marks)

7. A six cylinder two stroke single acting diesel engine running at ***120 rpm*** has a bore of ***900mm*** and a stroke of ***1300mm***. The effective brake torque is ***700 kNm***, mechanical efficiency ***94%*** and the brake specific fuel consumption is ***0.24 kg/kWh***. The calorific value of the fuel used is ***42 MJ/kg*** and the air to fuel ratio by mass is ***25:1***.

   a. The brake power developed (5 marks)

   b. The indicated thermal efficiency (5 marks)

   c. The indicated mean effective pressure (5 marks)

   d. If $1m^3$ of air at intake conditions has a mass of ***1.3kg***, calculate the volumetric efficiency (5 marks)

8. Steam enters the turbine of a steam power plant at ***50 bar*** and ***400 ^{0}C*** and exhausts to the condenser at ***0.1 bar***. The turbine produces a power of ***20 MW*** with an isentropic efficiency of ***85%***.

   a. The condition of the steam after the expansion in the turbine (4 marks)

   b. The mass flow rate of the steam (4 marks)

   c. Heat rejection in the condenser (4 marks)

   d. The thermal efficiency of the plant and compare it with Carnot cycle efficiency (8 marks)

9.

   a. Draw the flow diagram of a simple vapour compression refrigeration system and explain its working procedure. ***(05 marks)***

   b. Represent the relevant processes on *T-s* and *P-h* diagrams. ***(03 marks)***

   c. A ***17.5kW*** Freon-12 refrigeration plant has saturated suction temperature of ***-5^{0}C***. The condensation takes place at ***32^{0}C*** and there is no under cooling of refrigerant liquid occurred. Assuming isentropic compression of same, find:

      i. COP of the plant ***(04 marks)***

      ii. Mass flow rate of refrigerant ***(04 marks)***

      iii. Power required running the compressor in kW. ***(04 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 Any Six Questions**
- **Date: 2017.04.28** **Pass Mark 50%**

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

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1.

a. Resolve into partial fraction

i. $\dfrac{2x^2-3}{x^2(2x-1)}$ (5 marks)

ii. $\dfrac{x^3-2x+3}{4x^2-1}$ (5 marks)

b. Determine the coefficients A,B and C

$$f(x) \equiv 12x^3+16x^2-5x-3=(2x-1)(Ax^2+Bx+C)$$

Hence find the other factors of the function (5 marks)

c. If $5^{3x+1}-5^{3x}-3^{x+3}+3^{x+2}=0$,estimate the value of x (5 marks)

2.

a. Suppose$y = 2x^3$. Find the slope of the line tangent to the curve where x = 1. (4 marks)

b. If $z=\dfrac{xy}{x-y}$ show that $\dfrac{\partial^2 z}{\partial x^2}+2\dfrac{\partial^2 z}{\partial x \partial y}+\dfrac{\partial^2 z}{\partial y^2}=\dfrac{2z}{xy}$ (8 marks)

c. If $u = e^x siny$, find first order and second order partial derivatives (8 marks)

3.

a. Find all the roots of the function, $x^3+1=0$ and mark them in an Argand diagram (8 marks)

b. Determine the square root of $2+i$ (4 marks)

c. Using the arithmetic operations of complex numbers, Prove that

i. $(Cos\theta + i\,Sin\theta)^2 = Cos\,2\theta + i\,Sin\,2\theta$ (4 marks)

ii. $(Cos\theta + i\,Sin\theta)^{-2} = Cos\,2\theta - i\,Sin\,2\theta$ (4 marks)

4.

a. Evaluate the determinant $\begin{vmatrix} 2 & 4 & 12 \\ 3 & 9 & 8 \\ 4 & 16 & 6 \end{vmatrix}$ (3 marks)

b. Solve the equation $\begin{vmatrix} 1+x & 2 & 3 \\ 1 & 2+x & 3 \\ 1 & 2 & 3+x \end{vmatrix} = 0$ (7 marks)

c. Solve the following system of equations using Cramer's Rule. (10 marks)

$$x - y + z = 2$$
$$-2x + z = 5$$
$$3x + 2y + z = 4$$

5.

a. If $Cos\theta + Cos\phi = x$ and $Sin\theta + Sin\phi = y$ Prove that

i. $Sin\frac{1}{2}(\theta+\phi) = \pm\frac{y}{\sqrt{x^2+y^2}}$ (4 marks)

ii. $Cos\frac{1}{2}(\theta-\phi) = \pm\frac{1}{2}\sqrt{x^2+y^2}$ (4 marks)

b. If $Cos\,x + 2Sinx = 1$ show that $Tan\frac{x}{2} = 0 \text{ or } 2$ (4 marks)

c. Find all the solution of the following equations between 0 and π rad

i. $Cot\,x + Cot\,2x = 0$ (4 marks)

ii. $2Sin\,\theta - Tan\,\theta = 0$ (4 marks)

6.

a. A farmer has 2400 ft of fencing and wants to fence off a rectangular field that borders a straight river. He needs no fence along the river. He wants to find the dimensions of the field to get the largest area.

i. Formulate mathematical equations with proper variables (4 marks)

ii. What are the dimensions of the field that has the largest area? (8 marks)

b. Sum of one number and twice of the other number is 500. Find two numbers (non-negative) such that their product is maximum. (8 marks)

7.

a. Evaluate the following integrals

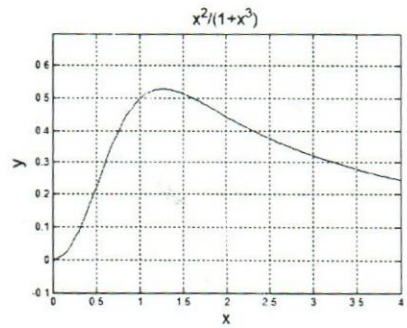
i. $\int\left(x^3+\frac{1}{\sqrt{x}}\right)^2 dx$ (5 marks)

ii. $\int\frac{x^2+1}{x+1}dx$ (5 marks)

iii. $\int_0^{\pi/4}\tan^2 x\,dx$ (5 marks)

b. Find the area enclosed by the curves $y^2=4x$ and $x^2=4y$ (5 marks)

8. Figure represents the function, $y=\frac{x^2}{1+x^3}$ in the $0\le x\le 4$



a. Evaluate the area under the curve given by the integral, $\int_0^4\frac{x^2}{1+x^3}dx$ (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)

9.

a. Find vertical and horizontal asymptotes of $f(x)=\frac{1}{x^2+2x}$ (5 marks)

b. Find and classify all critical points of $f(x)$ (8 marks)

c. Sketch the curve of the function$y=f(x)$. (7 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

ELECTROTECHNOLOGY

- **TIME ALLOWED - THREE HOURS**
- ***Answer FOUR (04) Questions from Part A and answer TWO (02) Questions from Part B***

Date: 2017.04.27

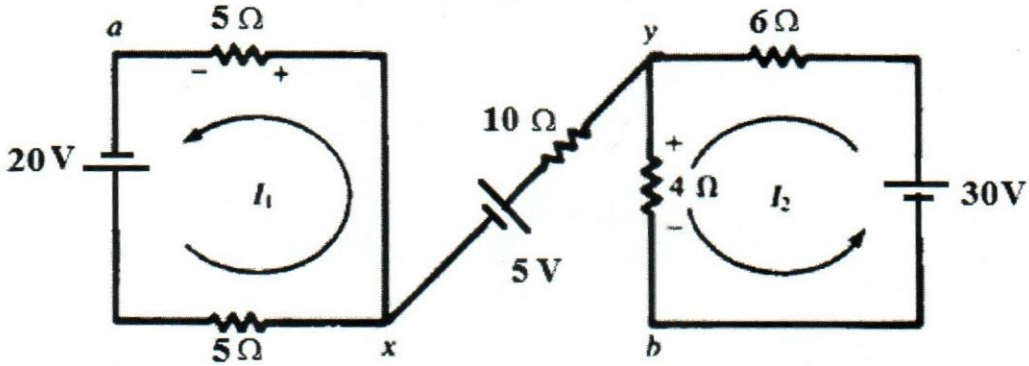
Answers with clear sketches/diagrams, neat handwriting and clear expression will get full marks

Part A

1. i. A length of wire has a resistance of 4.5 Ω. Find the resistance of another wire of the same material three times long and twice the cross-sectional area. (04 Marks)

   ii. State Kirchhoff's laws for electrical circuits. (04 Marks)

   iii. Find the voltage I_1, I_2 and Vab in the following network. (08 Marks)



2. A 230 V, 50 Hz a.c. supply is applied to a coil of 0.06 H inductance and 2.5 Ω resistance connected in series with a 6.8 μF capacitor.

   i. Draw phase diagram for R-L-C AC circuit. (04 Marks)

   ii. Calculate (08 Marks)

   a) impedance b) Phase angle between current and voltage

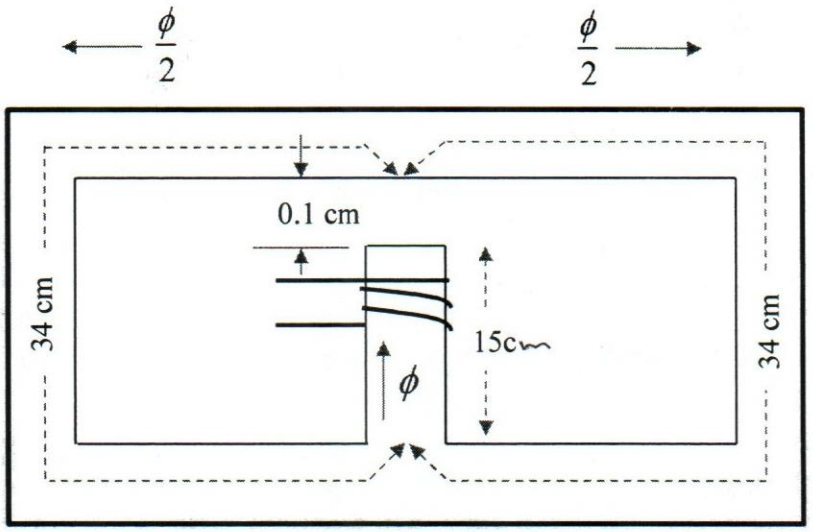
   c) Calculate power consumption d) resonance frequency

   iii. Determine equations for voltage and current. (04 Marks)

3. i. State Ampere's work rule for magnetic circuit. (04 Marks)

   ii. Briefly explain magnetic leakage and fringing effect. (04 Marks)

iii. A magnetic circuit made of wrought iron is arranged as shown below. The central limb has a cross-sectional area 8cm^2 and each of the side limbs has a cross-sectional area of 5 cm^2. Calculate the ampere-turns required to produce a magnetic flux of 1 mWb in the central limb, assuming the magnetic leakage is negligible. Given that for wrought iron
$H = 500\ AT/m\ at\ B = 1.25\ Wb/m^2$ and $H = 200\ AT/m\ at\ B = 1\ Wb/m^2$
(Permeability of air $\mu_o = 4\pi \times 10^{-7}$). (08 Marks)



4. i. Define the self inductance. (04 Marks)

ii. Derive the equation for self inductance of coil of N turns carrying a current I Amperes. (04 Marks)

iii. An air cored solenoid having a diameter of 4 cm and a length of 60 cm is wound with 4000 turns. If a current of 5A flows in the solenoid. Calculate the inductance and energy stored in joules. (Permeability of air $\mu_o = 4\pi \times 10^{-7}$) (08 Marks)

5. i. Name the three methods motor can be started, which consume less power. (04 Marks)

ii. Explain operation of all three methods, with a help of sketches. (04 Marks)

iii. A dual wound induction motor is arranged create 6 and 10 poles stator magnetic fields. Estimate the rated speeds assuming that the rotor slips by 4% and the power supply is at a frequency of 50 Hz. (08 Marks)

6. i. Draw shunt generator circuit diagram and write equation for terminal voltage. (04 Marks)

ii. Briefly describe the power losses of D.C. generator and motor. (04 Marks)

iii. A D.C. shunt machine when run as a motor on no-load takes 440 W and runs at 1000 r.p.m. The field current and armature resistance are 1A and 0.5Ω respectively. Calculate the efficiency of the machine when; (08 Marks)

a) Running as a generator delivering 40A at 220V

b) As a motor taking 40A from a 220V supply.

Part B

7. i. State condition for paralleling alternator with live bus bars. (05 Marks)

   ii. State different methods, AC generator synchronizing. (05 Marks)

   iii. Explain briefly with a circuit diagram any of the methods stated in(d). (06 Marks)

8. i. Explain the terms " *Shore supply connection* "and "*Alternative Maritime Power supply*" and briefly explain what are the shore supply connection requirements. (04 marks)

   ii. Explain the term "Preferential Tripping" how it is provided in shipboard practices. (04 marks)

   iii. What are the requirements pertaining to Installation and operation of Ship's Emergency Generator. (04 marks)

   iv. Explain why Instrument transformers are used. Explain with a diagram how KILOWATT meter is connected to Busbar using instrument Transformers. (04 marks)

9. i. Explain the term "Rotating Magnetic Field" relating to A.C. three phase rotating machines (04 marks)

   ii. What are the requirements of a Marine AVR with regards to the allowable Voltage Dip correction time and maximum offset. What are factors which would cause Voltage dip on an AC circuit. (06 marks)

   iii. With a Simple diagram explain a soft starting system used on an Induction motor. (06marks)

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 SIX questions only**
- **Date: 2017.04.26** **Pass marks: 50%**

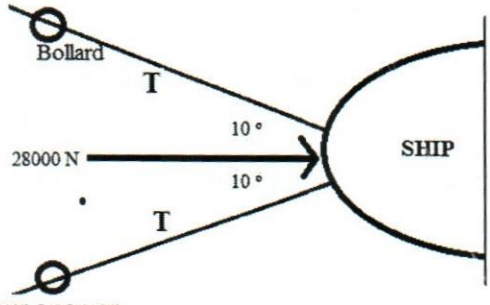
Answers with clear sketches/diagrams, neat handwriting and clear expression will get full marks

Density of Water – 1000 kgm^{-3} | Gravitational acceleration – 9.81 ms^{-2}
Density of Sea Water – 1100 kgm^{-3}

1.

1.1. What are the conditions for equilibrium under three coplanar forces ? (06 Marks)

1.2. A ship is in a dock and is secured to bollards on the harbour walls by two thick ropes. It is facing into a very strong wind which is putting a force of 28 000 N on the ship.



i. Calculate the tension *T* in the rope, the force at 90 degrees to the wind that is acting on the bottom bollard. Which direction is it acting in?

ii. What is the overall force acting on the ship? Explain your answer.

iii. The bottom bollard was not very well put in, and it gets ripped out of the harbour wall. Calculate the resultant force acting on the ship immediately after the bollard gives way, and state the direction relative to the wind. (0° is parallel to the wind)

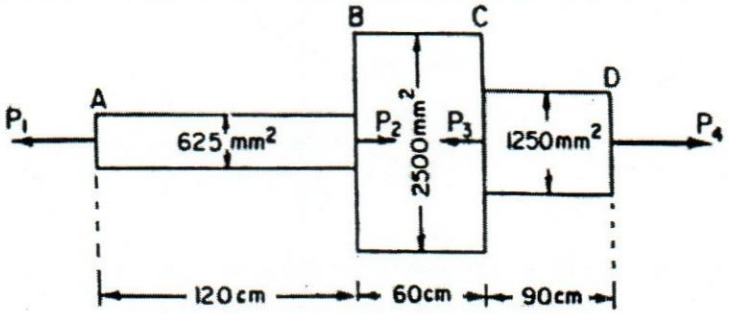
(14 Marks)

2. Single start square threaded bolt with core diameter 24 mm and pitch of 6 mm is tightened by a screwing a nut having mean diameter of bearing surface of 60 mm. Coefficient of friction for nut and bolt is 0.1 and for nut and bearing surface is 0.25. Determine total torque required to raise the axial load of 25 kN. (20 Marks)

3.1. Derive the equation for kinetic energy of a body in a leaner motion. Deduce the equation for rotational kinetic energy of a body from that. (06 Marks)

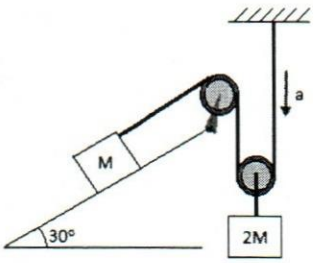
3.2. Delivery trucks that operate by making use of energy stored in a rotating flywheel have been used in Europe. The trucks are charged by using an electric motor to get the flywheel up to its top speed of 624 rad/s. One such fly wheel is a solid, homogeneous cylinder with a mass of 512 kg and a radius of 97.6 cm. (a) What is the kinetic energy of the flywheel after charging? (b) If the truck operates with an average power requirement of 8.13 kW, for how many minutes can it operate between charging's? (14 Marks)

3. A member ABCD is subjected to point loads P_1, P_2, P_3 and P_4 as shown. Calculate the force P_2 necessary for equilibrium if P_1 = 45 kN, P_3 = 450 kN and P_4 = 130 kN. Determine the total elongation of the member, assuming the modulus of elasticity to be 2.1×10^5 N/mm^2. (20 Marks)



4.

5.1. Show that acceleration of block of mass in the figure is one sixth of the gravity. All the surfaces are frictionless and the pulleys and the string are light. (10 Marks)



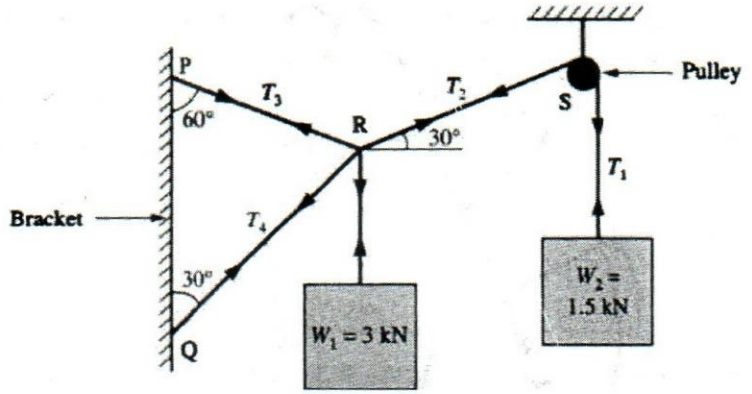
5.2. A block A of mass 0.5 kg can slide on a frictionless incline of angle 30◦ and length 0.8 m kept inside an elevator going up with uniform velocity 2m/s. Find the time taken by the block to slide down the length of the incline if it is released from the top of the incline. (10 Marks)

5. A single-plate clutch transmits 25 kW at 900 rpm. The maximum pressure intensity between the plates is 85 kN/m2. The outer diameter of the plate is 360 mm. Both the sides of the plate are effective and the coefficient of friction is 0.25. Determine,

(i) the inner diameter of the plate,

(ii) the axial force to engage the clutch. (20 Marks)

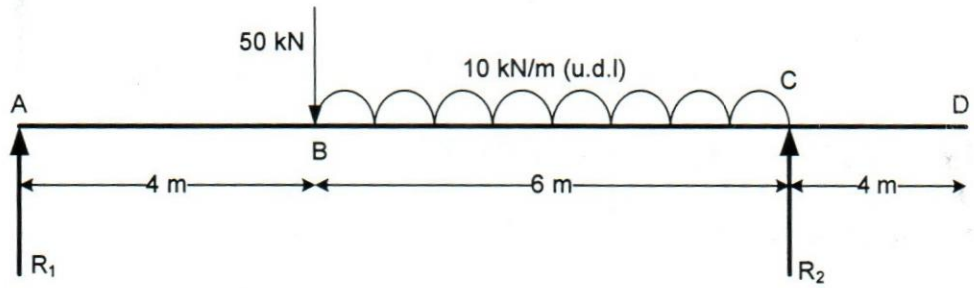
6. A bracket of PQR carries two weights W_1 and W_2 3 kN and 1.5 kN respectively, suspended from the point R as shown in the figure. Neglecting friction in the pulley S, determine the forces in the bars PR and QR of the bracket. (20 Marks)



7. Beam ABCD as given in figure supports with two reactions R_1 and R_2. A point load of 50 kN is applied at B and uniformly distributed load (u.d.l) of 10 kN/m is applied through B to C.

i. Draw the Bending moment diagram and shear force diagram (16 Marks)

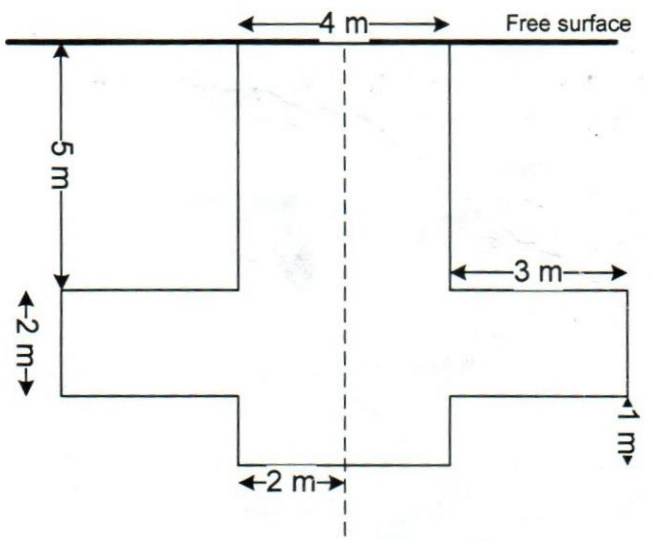
ii. What is the maximum bending moment and point where it occurs. (04 Marks)



8.

9.1. Define centre of pressure. (04 Marks)

9.2. Plane sheet as shown in figure is vertically immersed in a water tank such that top edge touches with free surface. Determine total pressure force and position of centre of pressure. (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 & SHIP CONSTRUCTION

- **Time Allowed - Three Hours**
- *Answer Four (04) Questions From* ***Part A****, And Two(2) Questions From* ***Part B***
- **Date: 2017.04.25** **Pass Mark 50%**

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

Part A

1. a) State Simpson's first (1/3) rule and indicate the shape of which the curve is approximated to. (2 Marks)

   b) Half breadth values which are measured at equal intervals from end to end of a water plane of length 60 m are as below.

0 m	1.9 m	3.8 m	5.9 m	8.9 m	4.6 m	2.6 m

   Find the followings

   i. Area of water plane (6 Marks)
   ii. TPC at that draft in SW (2 Marks)

   c) If the fresh water density is 1.0 t/m^3 prove that Statutory Fresh Water Allowance is equal to

$$\frac{\Delta}{40TPC}$$ (6 Marks)

2. a) Define following terms.
   i. Longitudinal Center of Floatation (LCF) (2 Marks)
   ii. MCT1cm (2 Marks)
   iii. Mean Draft (2 Marks)

   b) A 170m long vessel floating at draft 6.85m forward and 7.50m aft. The hydrostatic data of the vessel at this condition are as follow.

   MCT1cm 300 t-m, TPC 28, LCF 3.5m forward of midship.
   Following changes in loading have been taken place in the port;
   160 tonnes added 63m aft of midship
   200 tonnes added 27m forward of midship
   120nnes removed 75m aft of midship

i. What are final forward & aft draft of the vessel. (5 Marks)
ii. Find the mean draft of the vessel after completion of above operation. (5 Marks)

3. a) What is mean by the Transvers Metacenter of a ship. (2 Marks)

b) State the reason why Inclining Experiment is carried out to a ship. (2 Marks)

c) List down the conditions to be observed before & during Inclining Experiment. (8 Marks)

d) A vessel of light displacement 5600MT in seawater carried out the inclining experiments. A weight of 34MT was shifted transversely across the deck by 12 m. If the length of the plumb line was 5.6 m and deflection was 45 cm. Find the Metacentric Height (GM) of the of the vessel at lightship condition. (4 Marks)

4. A vessel of 10,000 t displacement having heavy lift crane fitted on main deck and the derrick head is 12m above the deck. 150 tonnes of cargo stored in lower cargo hold having CG 10 meters below the main deck to be shifted using the crane and to be placed on main deck, 15m forward of its original position, to facilitate some additional cargo to be loaded into lower hold at this port.

a) Calculate the shift of center of gravity of the ship from its original position when the cargo is;
i. Just clear of the deck (2 Marks)
ii. At the derrick head (2 Marks)
iii. In its final position (2 Marks)

b) If transvers Metacenter is 6.8 m above the keel & the initial vertical center of gravity was 6.65 m above the keel;
i. Find the new GM of the vessel. (4 Marks)
ii. Describe the conditions of static stability of the vessel at each conditions stated in a) (6 Marks)

5. a) Explain following terms
i. Frictional Resistance of a ship (3 Marks)
ii. Residuary Resistance of a ship (3 Marks)

b) A ship to be designed to have following criteria Length 150m, wetted surface area 5400 m^2 service speed 16 knots. A model ship of 3.5 m long towed at corresponding speed found residuary resistance of the model is equal to 6.8 N. The frictional coefficient (f) for the ship in seawater density 1.025 tonne/m^3 is 1.42 and index for speed (n) equal to 1.83 when speed is measured in m/s. Find the effective power of ship at her service speed.
Note: at corresponding speeds $R_r \propto L^3$ where R_r is the residuary resistance & L is the length of the vessel. (10 Marks)

6. a) Define the following terms.
   i. Theoretical Speed (2 Marks)
   ii. Apparent Slip (2 Marks)
   iii. Wake (2 Marks)
   iv. Speed of Advance (2 Marks)

   b) A ships propeller 4.28m in diameter and the pitch ration is 1.1. At MCR of the Main Engine propeller turns at 120 RPM vessel travels at 16.0 Knots and the wake fraction is 0.18 . Find;
   i. Apparent Slip (4 Marks)
   ii. Real Slip (4 Marks)

Part B

7. a) State three (03) systems used to protect the underwater area of the hull from corrosion. (6 Marks)

   b) Briefly explain how the corrosion of the hull is prevented from any of the two (02) systems that you have stated in a) (10 Marks)

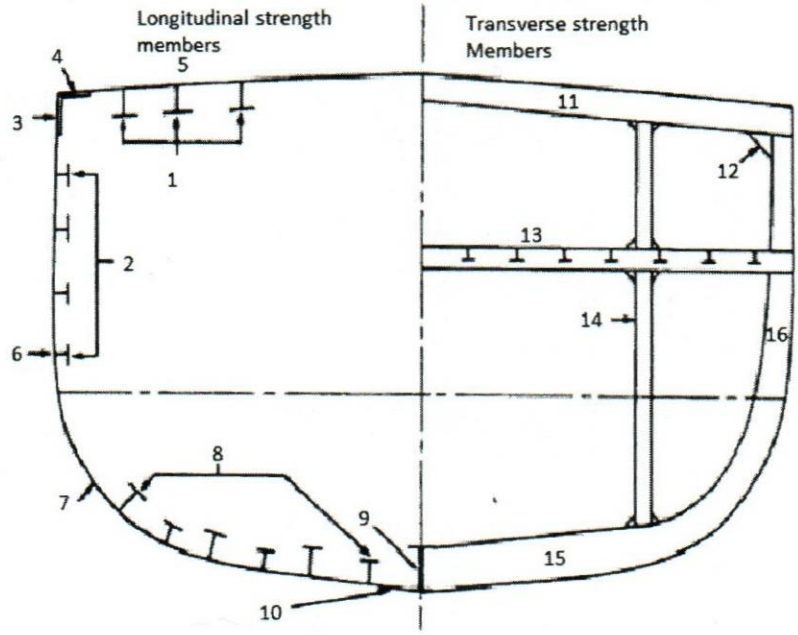
8. a) Explain the term "Reserve Buoyancy". (3 Marks)

   b) Name the types of bulkheads found on board ship. (3 Marks)

   c) What are the advantages of bulkheads used in ship construction. (4 Marks)

   d) Briefly describe two (02) type of main bulkheads that could find on a sea going ships structure. (6 Marks)

9. a) A ship structure is made of several types of steel profiles welded together to withstand the stresses expected to be acting on it during the service life. Identify & name the longitudinal and transverse structural components in the given sketch indicated from 1 to 16. (8 Marks)



   b) Briefly describe the following phenomenon with regards to the stresses and loads acting on the hull girder of a ship & state the names of supporting structural components fitted on hull to withstand those.

   i. Hogging & Sagging
   ii. Pounding
   iii. Racking
   iv. Panting (8 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 any SIX questions**

Date: 2016.05.02 **Pass mark 50%**

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

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

a. Draw a ***T-h diagram*** for a vapour representing saturated liquid line, wet vapour region, dry vapour line, super heated vapour region and the critical point (5 marks)

b. A closed vessel of $0.8\ m^3$ capacity contains dry saturated steam at ***3.5 bar***. 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 (6 marks)

iii. The amount of heat transferred during the cooling process (6 marks)

2.

a. Define the High calorific value and Low calorific value of a fuel (4 marks)

b. A fuel composition by mass is Carbon ***75 %***, Hydrogen ***8 %***, Oxygen ***6 %*** and remainder incombustible. ***16 kg*** of air is supplied per kg of fuel during the combustion. Calorific values of Carbon and Hydrogen are ***33.7*** and ***144 MJ/kg*** respectively. Find

i. The calorific value of the fuel (3 marks)

ii. The stoichiometric air/fuel ratio (3 marks)

iii. The percentage of excess air (4 marks)

iv. The percentage of each products of combustion (6 marks)

3. A spark-ignition engine works an air-standard Otto cycle that has a heat addition of ***600 kJ/kg*** and compression ratio of ***7***. The pressure and temperature at the beginning of the compression process are ***0.9 bar*** and ***283 K***. Determine

i. The temperature and pressure after compression (4 marks)

ii. The maximum pressure and temperature of the cycle (4 marks)

iii. The temperature and pressure at the end of expansion (4 marks)

iv. Thermal efficiency (4 marks)

v. The mean effective pressure (4 marks)

4.

a. Draw a PV diagram to represent processes in an ideal Diesel cycle and write an expression for thermal efficiency of the cycle using cardinal point temperatures. (4 marks)

b. At the beginning of compression in an ideal air-standard ***Diesel cycle*** the temperature and pressure are ***300 K*** and ***200 kPa***. After the combustion is complete, temperature and pressure become ***1500 K*** and ***7.0 MPa***. Find

i. The compression ratio (4 marks)

ii. Temperature at the end of compression (4 marks)

iii. Heat addition per kg during the combustion (4 marks)

iv. The thermal efficiency (4 marks)

5. A cold room wall is ***100 mm*** thick and has a thermal conductivity of ***0.14 W/m K***. It is lined internally with ***80 mm*** of cork which has a thermal conductivity of ***0.052 W/m K***. The surface heat transfer coefficient of both exposed surface is ***11.5 W/m^2 K***. The ambient temperature is ***22 ^0C*** and the heat transfer rate is ***35 W/m^2***.

a. Determine

i. The overall heat transfer coefficient (5 marks)

ii. The temperature of the air in the cold room (5 marks)

iii. The temperature at the cork/wall interface (5 marks)

b. What is the thickness of cork required to reduce the heat transfer rate to 10 ***W/m^2*** under same temperature condition? (5 marks)

6. Steam is the working fluid in an ideal Rankine cycle. Dry saturated vapour enters the turbine at ***8.0 MPa*** and saturated liquid exits the condenser at a pressure of ***0.08 MPa***. The net power output of the cycle is ***100 MW***.

a. Determine

i. Dryness fraction after the expansion of steam in the turbine (3 marks)

ii. The mass flow rate of steam in kg/h. (3 marks)

iii. The Rankine efficiency of the cycle (3 marks)

iv. The rate of heat transfer from condensing steam as it passes through the condenser in kW (3 marks)

b. Draw the ***TS*** diagram (4 marks)

c. Determine the mass of coal burn in kg/h if the boiler thermal efficiency is 68% and the calorific value of the coal used is ***34.7 MJ/kg*** (4 marks)

7. In a ***R-717*** refrigerating plant, the refrigerant enters the condenser as a dry vapour and leaves as a saturated liquid at ***10.34 bar***. The evaporator pressure is ***2.265 bar***. If the circulation of the refrigerant through the plant is ***4 kg/min***,

a. Draw the ***TS*** and ***PH*** diagram to represent each process in the cycle (4 marks)

b. Calculate

i. The dryness fraction at inlet to the evaporator (2 marks)

ii. The dryness fraction at the evaporator outlet (2 marks)

iii. The refrigerating effect per minute (4 marks)

iv. The Coefficient of performance (4 marks)

v. The volume of refrigerant taken in to the compressor per minute (4 marks)

8. A four-cylinder, single acting, two-stroke engine develops ***300 kW*** indicated power when the mean effective pressure is ***628 kPa*** and the speed is ***4.5 rev/s***. The stroke length is ***25%*** greater than the cylinder diameter. The mechanical efficiency of the engine is ***72 %*** and the indicated specific fuel consumption is ***0.225 kg/kWh***. The calorific value of the fuel used is ***42 MJ/kg***. Determine

i. The diameter of the cylinder (4 marks)

ii. The brake power and brake torque (4 marks)

iii. Indicated thermal efficiency (6 marks)

iv. Brake thermal efficiency (6 marks)

9. A ***0.05 kg*** of steam at ***15 bar*** is contained in a rigid vessel of volume ***0.0076 m^3***.

a. What is the temperature of the steam? (5 marks)

b. If the vessel is cooled, at what temperature will the steam be just saturated? (5 marks)

c. Cooling is continued until the pressure in the vessel is ***11 bar***. Calculate the final dryness fraction of the steam, and the heat rejected between the initial and final states. (10 marks)

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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. All questions carry equal marks.**

Date: 2017.01.02

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

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

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1. $1m^3$ of air at ***120 kPa*** and ***27 ^0C*** 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 ***57 ^0C***. 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 ***75%***, Hydrogen ***8%***, 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. Stoichiomatric 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 ***144MJ/kg*** respectively.

b. A boiler delivers ***2000 kg*** of steam per hour at a pressure of ***7 bar*** and with a dryness fraction of ***0.98***. The feed-water to boiler is at a temperature of ***48 ^0C***. 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. 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 ***-15 ^0C*** and an ambient temperature of ***27 ^0C***. Calculate

   a. The minimum thickness of insulation (4 marks)

   b. The inner surface temperature (4 marks)

   c. The interface temperature between the inner layer of wood and insulation (4 marks)

   d. The interface temperature between the outer layer of wood and insulation (4 marks)

   e. 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 W/m^2 K***

4. Air at a temperature and pressure of 300K and 1bar is taken through an Otto cycle consisting of the following four non-flow processes:

   a. Isentropic compression through a volumetric compression ratio of 6.
   b. Heat addition at constant volume of 1400kJ/kg of air.
   c. Isentropic expansion to the original volume.
   d. Heat rejection at constant volume.

   Calculate the cycle efficiency and mean effective pressure. (20 marks)

5. In an ideal ***Diesel cycle*** the volume compression ratio is ***14:1*** and fuel is admitted for ***10%*** of the stroke. The conditions of air at beginning of compression are ***35 ^0C*** and ***1.03 bar***. Determine

   a. Temperature and pressure at the end of compression (4 marks)

   b. The maximum temperature of the cycle (4 marks)

   c. The work transfer per cycle for ***1kg*** of air (4 marks)

   d. The mean effective pressure (4 marks)

   e. The cycle efficiency (4 marks)

6. A water cooled compressor driven by an engine takes in ***8 m³*** of air per minute at ***300 K*** and ***1 bar*** and delivers it at ***7 bar***. The compression index is ***1.25*** and the mechanical efficiency of the compressor is ***85%***.

   a. Determine

      i. Temperature after the compression (4 marks)

      ii. Indicated power of the compressor (4 marks)

      iii. Shaft power and friction power (4 marks)

   b. Due to a partial failure of water cooling system, the compression index raises to ***1.3***, find the increase in shaft power of the engine. (8 marks)

7. A six cylinder, single acting, four stroke oil engine, of ***200 mm stroke*** and ***225 mm bore*** runs at ***5 rev/s*** when the mean effective pressure is ***8.5 bar***. The fuel consumption rate is ***10.2 kg/h*** and calorific value of the fuel is ***44.2 MJ/kg***. If the mechanical efficiency is ***85 %***, determine

   a. Indicated power (5 marks)

   b. Brake power (5 marks)

   c. Brake specific fuel consumption (5 marks)

   d. Brake thermal efficiency (5 marks)

8. Steam is supplied to a turbine at ***30 bar 350 ^{0}C*** and the condenser pressure is ***0.045 bar***. The power developed is ***5 MW*** when the steam consumption is ***22.5 Mg/h***. Determine

   a. The heat supplied per kg in boiler (5 marks)

   b. Dryness fraction after expansion in turbine (5 marks)

   c. The ideal efficiency of the Rankine cycle (5 marks)

   d. The Actual efficiency of the turbine (5 marks)

9.

   a. Briefly explain the vapour compression refrigeration system. (3 marks)

   b. Explain the effects of superheat and sub-cooling on the vapour compression refrigeration cycle. (5 marks)

   c. A 17.6 kW, R-12 refrigeration plant has saturated suction temperature of -5^{0}C. The condensation takes place at 30^{0}C. Compressor receives dry saturated vapour and no sub-cooling. Assuming isentropic compression, find:

      i. Power required to run the compressor in kW (4 marks)

      ii. COP of the plant (4 marks)

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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 FOUR (04) Questions from Part A and answer TWO(02) Questions from Part B***

Date: 2016.12.29

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

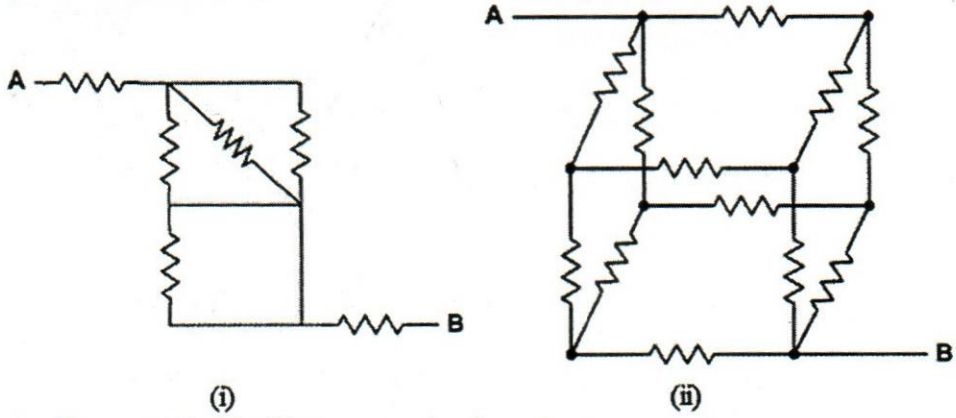
Part A

1. ***a)*** Express Faraday's laws of electromagnetic induction. ***(03 marks)***
   b) Explain statically induced e.m.f. and dynamically induced e.m.f. ***(03 marks)***
   c) If the magnetic flux linkages (ϕ) of the coil and current (I) are known, then the inductance of coil with N turns can be determined by $L = \frac{N\phi}{I}$. Hence, derive equation for inductance in terms of reluctance. ***(04 marks)***
   d) A wooden toroid of mean diameter 400 mm and cross sectional area 400 mm^2 is uniformly wound with a coil of 1000 turns which carries a current of 2A. Determine ***(06 marks)***
   i. Self inductance of the coil
   ii. The e.m.f induced in the coil when the current is uniformly reduced to zero in 10 ms.

2. A 230 V, 50 Hz a.c supply is applied to a coil of 0.06 H inductance and 2.5 Ω resistance connected in series with a 6.8 μF capacitor.
   a) Draw phasor diagram for above R-L-C series circuit. ***(04 marks)***
   b) Calculate ***(04 marks)***
   i) Impedance
   ii) Current ***iii)*** power utilization.
   c) Derive equation for voltage and current with phase angle and frequency. ***(04 marks)***
   d) Find resonance frequency of above R-L-C series circuit. ***(04 marks)***

3. ***a)*** Find the resistance of 1000 meters of a copper wire 25 mm^2 in cross-section. The resistance of copper is 1/58 ohm per meter length and 1 mm^2 cross-section. What will be the resistance of another wire of the same material, three times as long and one-half the cross-sectional area? ***(04 marks)***

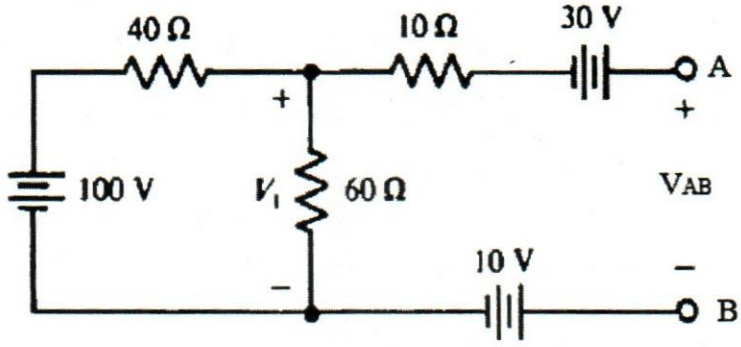
b) Determine the equivalent resistance of following networks if all resistors are $1\ \Omega$. *(04 marks)*



(i) (ii)

c) Express Kirchhoff current and voltage laws. *(02 marks)*

d) Find voltage V_1 and V_{AB}. *(06 marks)*



4. *a)* Define the terms magnetic flux density and magnetic intensity. *(03 marks)*

b) Express magnetic reluctance formula in terms of material properties and dimensions. *(03 marks)*

c) An iron ring has a mean diameter of 15 cm, a cross-sectional area 20 cm^2 and a radial gap of 0.5 mm cut in it. It is uniformly wound with 1500 turns of insulated wire and a magnetizing current of 1A produces a magnetic flux of 1 mWb. Neglecting the effect of magnetic leakage and fringing and permeability of air $\mu_0 = 4\pi \times 10^{-7}\ H/m$., Calculate

i. Reluctance of the magnetic circuit. *(05 marks)*

ii. Relative permeability of iron. *(05 marks)*

5. *a)* Explain power losses in a D.C. machine. *(04 marks)*

b) A d.c. shunt machine when run as a motor on no load takes 440W. The field current and armature resistance are 1A and $0.5\ \Omega$ respectively. Calculate the efficiency of the machine when

i. running as a generator delivering 40A at 220V. *(04 marks)*

ii. as a motor taking 40A from a 220V supply. *(04 marks)*

c) Explain behavior of d.c motor when the load on the motor is decreased. *(04 marks)*

6. *a)* Name three types of single phase AC motors *(04 marks)*

b) Name three types of DC Motors *(04 marks)*

c) Name two methods used to start 3 phase AC motors. *(04 marks)*

d) Speed of a prime mover connected to a AC generator is 1500 rpm. Frequency of the output voltage of generator is 50 Hz. Find the number of poles in the generator. *(04 marks)*

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Part B

7. *a)* Explain with reasons why protection equipment is essential in an electrical distribution System. ***(05 marks)***
   b) Draw a protective discrimination system and explain how it is achieved. ***(05 marks)***
   c) Explain THREE methods how overcurrent protection can be incorporated for electrical equipment. ***(06 marks)***

8. With regards to Shipboard High Voltage systems
   a) Give THREE reasons why High Voltage supply systems are required in Shipboard applications. ***(04 marks)***
   b) Name Permits required in order to carry out maintenance in High voltage equipment. ***(04 marks)***
   c) Explain clearly how High Voltage equipment can be isolated in order to carry out maintenance. ***(04 marks)***
   d) What kind of Circuit Breakers are used in interruptions of High Voltage equipment. ***(04 marks)***

9. *a)* By means of simple sketches show the difference between insulated and earthed neutral system with reference to 3-phase power supply. ***(06 marks)***
   b) Briefly explain with reasons which system is preferred on board ship. ***(06marks)***
   c) Draw a diagram showing earth fault lamps on a ships 3-phase electrical system. State how an earth fault is indicated. ***(04 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

NAVAL ARC & SHIP CONSTRUCTION

- **TIME ALLOWED - THREE HOURS**
- ***Answer SIX (06) QUESTIONS in All, Selecting Minimum Two Questions from Part B***

Date: 2016.12.27

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

Part A

1. The half ordinates of a waterplane 120 m long are as follows;

Section	*AP*	*½*	*1*	*1½*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*8½*	*9*	*9½*	*FP*
½ ord	*1.2*	*3.5*	*5.3*	*6.8*	*8.0*	*8.3*	*8.5*	*8.5*	*8.5*	*8.4*	*8.2*	*7.9*	*6.2*	*3.5*	*0 m*

Calculate

a) Area of waterplane ***(08marks)***

b) Distance of centroid from midships. ***(08marks)***

2.

a) A ship of 5000 tonne displacement has its centre of gravity 1.6 m aft of midships and 4.5 m above the keel. 250 tonne of cargo now added 48 m forward of the midship and 12 m above the keel. Calculate the new position of the centre of gravity. ***(08 marks)***

b) Calculate the new centre of gravity if that mass is moved to a position 8 m forward of the midship. ***(08 marks)***

3.

a) Explain the inclining experiment. ***(06 marks)***

b) A mass of 8 tonne is moved transversely through a distance of 15 m on a ship of 4500 tonne displacement, when the deflection of a 12 m pendulum is found to be 120 mm. the transverse metacenter is 7.3 m above the keel. Determine the height of the centre of gravity above the keel. ***(10 marks)***

4.

a) Explain the terms ***(02 marks each)***

i. Trimming moment
ii. TPC
iii. MCT1cm

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. ***(10 marks)***

5.

a) Name the factors, governing the frictional resistance of a ship. ***(04 marks)***

b) A ship is 125 m long, 16 m beam and floats at a draught of 7.8. Its block coefficient is 0.72. Calculate the power required to overcome frictional resistance at 18 knots if n = 1.825 and f = 0.423. Use taylor's formula for wetted surface area. C = 2.55 ***(12 marks)***

6.

a) Explain with an aid of a sketch relationship between various component of a ship speed i.e. Theoretical speed, ship speed, apparent slip, wake speed, speed of advance, real slip and negative apparent slip. ***(04marks)***

b) A ship of 12,400 tonne displacement is 120m long, 17.5m beam and floats at a draught of 7.5m. The propeller has a face pitch ratio 0.75, when turning at 100 revs/min, produces a ship speed of 12knots with a real slip of 30%. Calculate the apparent slip, pitch and diameter of the propeller. The wake fraction w may be found from the expression. $W=0.5C_b - 0.05$ ***(12 marks)***

Part B

7. Describe EACH of the following, stating what component parts of the ships structure help resist the effect.

a) racking ***(03 marks)***

b) water pressure effect ***(03 marks)***

c) panting ***(03 marks)***

d) pounding ***(03 marks)***

e) forward and aft sheer ***(02 marks)***

f) Sheer Strake ***(02 marks)***

8.

a) Sketch and describe the different floors used in the construction of a double bottom showing brackets, stiffeners, scallops, cutouts, floors, lightening holes, struts, bracket floors, solid floors, etc indicating where each type is employed. ***(06 marks)***

b) With reference to aft peak tank describe the members which are normally found in aft peak Tank construction. ***(06 marks)***

c) State type of welding and distinguish the difference between MIG and TIG welding. ***(04 marks)***

9. in relation to the collision bulkhead comment on following

a) position of the bulkhead relative to the length of the ship ***(03 marks)***

b) extent of the collision bulk head ***(03 marks)***

c) openings through the collision bulkhead ***(03 marks)***

d) compartments that forwarded of the bulkhead that may get filled in the event of a damage ***(03 marks)***

e) State the reasons for fitting bulbous bows ***(04 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 SIX QUESTIONS only. All questions carry equal marks.**

Date: 2016.12.28

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

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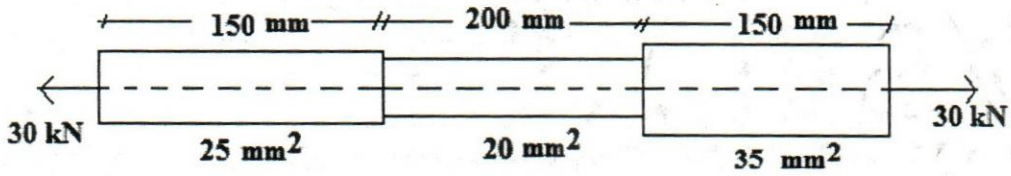
1.

1.1. Differentiate the terms Absolute velocity, mean velocity and average velocity. (6 Marks)

1.2. A particle is dropped from the top of a tower 100m high. Another particle is projected upwards at the same time from the foot of the tower, and meets the first particle at a height of 30m. Find the velocity with which the second particle is projected upwards. (14 Marks)

2. Calculate the power transmitted by a single plate clutch at a speed of 2000 r.p.m., if the outer and inner radii of friction surfaces are 150mm and 100mm respectively. The maximum intensity of pressure at any point of contact surface should not exceed $0.8 \times 10^5\ N/m^2$. Take both sides of the plate as effective and co-efficient of friction 0.3. Assume uniform wear. (20 Marks)

3. A copper bar shown in figure is subjected to a tensile load of 30 kN. Determine elongation of the bar, $E = 100\ GPa$. (20 Marks)



4. A train of mass 250 Mg, moving with a velocity of 65 km/h along a horizontal track, beings to climb up an incline of 1 in 80. During the climb the engine exerts a constant tractive force of 22 kN while the resistance to motion remains constant at 66 N per Mg. Determine,

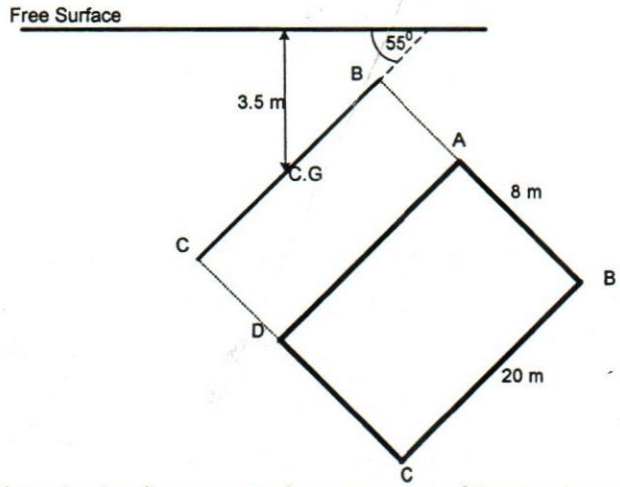
4.1. How far the train will move? (10 marks)

4.2. How long it will move, before coming to rest? (10 marks)

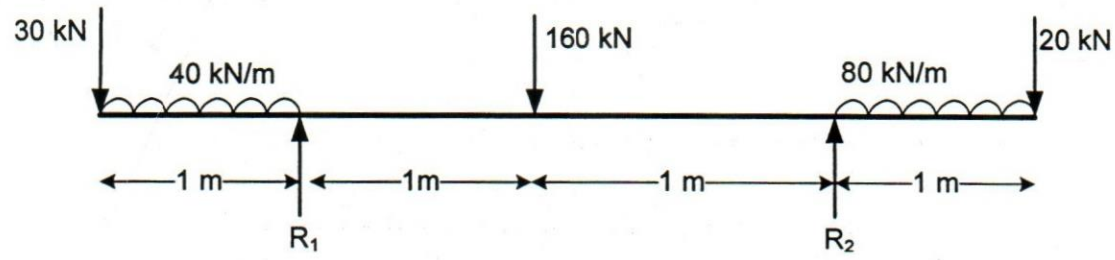
5.

5.1. Define term 'Centre of pressure' and 'total pressure force'. (5 marks)

5.2. A rectangular plate of ABCD is immersed on a liquid having relative density of 0.75 as shown on figure. Find the total pressure force acting on one side of the plate and position of centre of pressure. (15 marks)



6. A beam 4 m long is simply supported over a span of 2 m and overhangs both supports by the same amount. The right-hand overhanging portion carries a uniformly distributed load of 80 kN/m and a concentrated load of 20 kN at the extreme end; the left-hand overhanging portion carries a uniformly distributed load of 40 kN/m and a concentrated load of 30 kN at the extreme end; in addition a load of 160 kN is concentrated at mid-span.
Draw to scale the shear force and bending moment diagrams. (20 marks)



7.

7.1. Identify the **correct** statements. (6 marks)

[Wrong selections earn minus marks, under maximum 0 within the 7.1 question.]

i. Angle between limiting friction force and resultant (of limiting friction force and normal reaction) is called angle of friction.

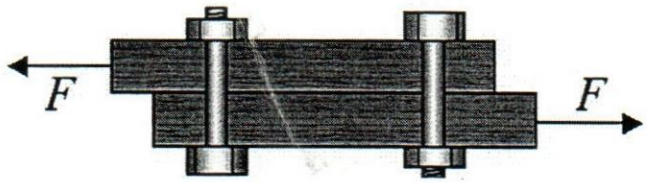
ii. Friction force is a vector but not a self adjusting force

iii. Angle of repose is equal to the friction angle.

iv. The moment of inertia can have either m^4 of kgm^2 as its standard units.

v. Every object in the absence of an external resultant force; moves with constant velocity.

7.2. Two boards are bolted together with two bolts, as shown. The squeeze force between the boards is 500 N. If the shear strength force of each bolt is 5000 N and the coefficient of static friction between the boards is $\mu_s = 0.5$, what is the maximum force *F* that can be applied to the boards and not pull them apart? (14 Marks)



8.

8.1. What is a helix angle of a screw profile? (5 marks)

8.2. A load of 25 kN is raised by means of a screw jack, having a single start square threaded screw of 14 mm pitch and mean diameter 55 mm. If a force of 120 N is applied at the end of a lever to raise the load, find suitable length for lever. Take coefficient of friction as 0.15. (15 marks)

9.

9.1.

a. Define Simple Harmonic Motion.

b. Derive an expression for frequency of vibration of a spring. (8 Marks)

9.2. A helical spring, negligible mass and which is found to extend 0.25 mm under a mass of 1.5kg, is made to support a mass of 60 kg. The spring and the mass system is displaced vertically through 12.5 mm and released. Determine the frequency of natural vibration of the system. Find also the velocity of mass, when it is 5 mm below its rest position. (12 Marks)

00033

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

ENGINEERING DRAWING

- **TIME ALLOWED - FOUR HOURS**
- **Answer all questions**
- **Date: 2016.09.02**

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

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Figure, on the insert, shows details of the component parts of a **Parallel Slide Stop Valve** which can be used on high pressure steam when placed in a pipe line.

Using a suitable scale, draw the following views of fully assembled **Parallel Slide Stop Valve** in **first angle projection**:

(a) Sectional elevation, showing the Valve in the **closed position**. The plane of the section should be through the branches.

(b) End elevation projected to the right of **(a)**

Suitable dimensions should be estimated where not provided. Complete the drawing by including the title, projection symbol, dimensions and a list of materials of parts.

Marking System

(i). Assembling accuracy of view (a)	(45 marks)
(ii). Assembling accuracy of view (b)	(30 marks)
(iii). Optimization of space	(05 marks)
(iv). Dimensioning	(05 marks)
(v). List of materials of parts	(05 marks)
(vi).Title block, projection symbol, lettering	(05 marks)
(vii). Final appearance, neatness	(05 marks)

000031

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 Arc & Ship Construction

- **Time Allowed - Three Hours**
- *Answer Four (04) Questions From* ***Part A****, And Two(2) Questions From* ***Part B***
- **Date: 2016.08.25** **Pass Mark 50%**

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

Part A

1. A ship 150 m long, 18 m beam, floats at an even keel draught of 7 m in sea water density 1025 kg/m3. The half area of immersed sections commencing from the after perpendicular (AP) are

Station	0	1	2	3	4	5	6	7	8	9	10
Half Areas of Immersed section(m^2)	10	26	40	59	60	60	60	56	38	14	4

Calculate
(a) The Displacement 4 Marks
(b) The Block Coefficient. 4 Marks
(c) The Prismatic Coefficient. 4 Marks
(d) The midship section area coefficient. 4 Marks

2. (i) Explain the inclining experiment. 6 marks

(ii) A mass of 8ton is moved transversely through a distance of 15m on a ship of 4500ton displacement, when the deflection of an 12m pendulum is found to be 120mm. the transverse metacenter is 7.3m above the keel. Determine the height of the centre of gravity above the keel. 10 marks

3. (a) Define Center of Buoyancy and show with the aid of sketches how a vessel which is stable will return to upright after being heeled by an external force. 4 Marks
(b) Explain the terms Neutral Equilibrium and Unstable Vessel with the aid of diagrams, with Regards to vessel's transverse stability. 4 Marks

(c) A Ship of 5000 tonne displacement has a rectangular double bottom tank 9 M wide and 12 M long, half full of sea water. Calculate the virtual reduction in metacenter due to Free surface. 8 Marks

4. If the Density of sea water is 1.025 t/m3 and the density of fresh water is 1.000 t/m3, prove that the Statutory Fresh Water Allowance is $\frac{\Delta}{40\,TPC}$ CM. 4 Marks

A ship of 22,000 tonne displacement has a draught of 9.00 m in river water of 1.008 t/m3. The waterplane area is 3200 m2. The vessel then enters sea water of 1.026 t/m3. Calculate the change in displacement as a percentage of the original displacement in order to :

(a) Keep the draught the same. 6 Marks
(b) Give a draught of 8.55 m. 6 Marks

5. A 7m model of a ship has a wetted surface area of $8m^2$. When towed at a speed of 4 knots in fresh water the total resistance is found to be 40 N. If the ship is 140m long, calculate the effective power of the corresponding speed. Take n=1,825 and Calculate f from the formula. SCF 1.16. 16 marks

6. (a) An expression used for the calculation of ship frictional resistance is $R_f = f\,S\,v^n$
1. Explain the terms S, v and n 2 Marks
2. What factors influence the value of coefficient f . 2 Marks

(b) A ship of 12000 tonne displacement travels at a speed of 14.5 knots when developing 3500 kW shaft power.
Calculate

(1) the value of Admiralty Coefficient. 4 Marks
(2) The percentage increase in shaft power required to increase the speed by 1.5 knots. 4 Marks
(3) The percentage increase in the speed of the ship if the shaft power is increased to 4000 kW. 4 Marks

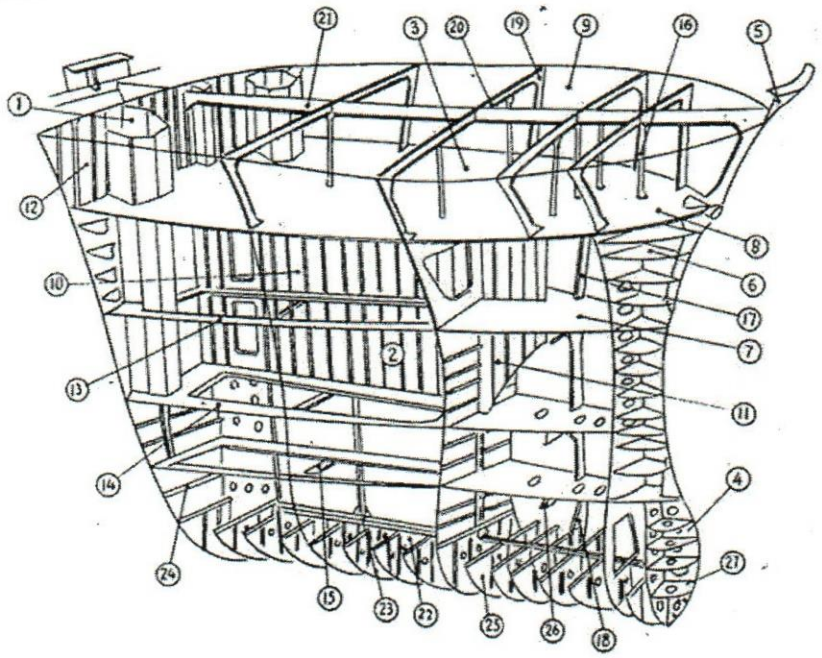
Part B

7.

i) Sketch the fore end construction of a ship you are familiar with — 12 marks
ii) State the reasons for fitting bulbous bows — 04 marks

8. (i) Sketch a transverse section of a double bottom tank in way of a bracket floor, naming the main structural members. — 8 marks

(ii) Identify the components of a bow construction of a ship given with numbers from 1 to 27. — 8 marks



9.

State the PURPOSE of each of the following and describe where they are located in the ship structure

a) Duct keel — 2 marks
b) forward and aft sheer — 2 marks
c) Hawse Pipe — 3 marks
d) Spurling Pipe — 3 marks
e) Torsion box — 3 marks
f) Freeing ports — 3 marks

4B.

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 Six Questions**
- **Date: 2016.08.29** **Pass Mark 50%**

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1. *a)* State impedance equation of R-L-C series circuit. ***(04 marks)***

   b) Express behavior of R-L-C series circuit when reactance of inductor is equals reactance of capacitor. ***(04 marks)***

   c) A 230 V, 50 Hz a.c. supply is applied to a coil of 0.06 H inductance and 2.5 Ω resistances connected in series with a $6.8\mu F$ capacitor. Calculate ***(08 marks)***

   i. impedance

   ii. current

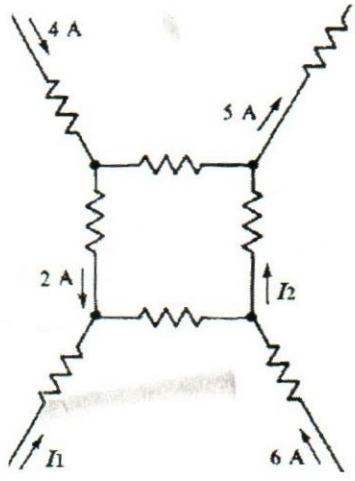
   iii. phase angle between current and voltage

   iv. power factor

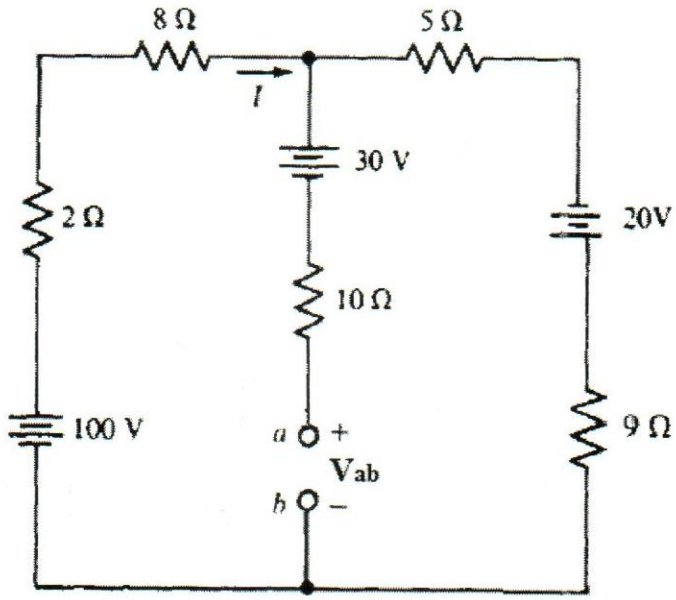
   v. power consumed

2. a) State Kirchhoff's laws for electrical circuits ***(04 marks)***

   b) Find the indicated unknown currents in the circuit. ***(04 marks)***



c) Find V_{ab} and power consumption of 10 Ω resistor in the circuit *(08 marks)*



3. a) Define the terms magnetic flux density and magnetic flux intensity. *(04 marks)*

b) What is the relation between magnetic flux density and magnetic flux intensity? *(04 marks)*

c) An iron ring has a mean diameter of 15 cm, a cross-section area of 20 cm^2 and a radial gap of 0.5 mm cut in it. It is uniformly wound with 1500 turns of insulated wire and a magnetizing current of 1 A produces a magnetic flux of 1mWb. Neglecting the effect of magnetic leakage and fringing (permeability of air $\mu_0 = 4\pi \times 10^{-7} H/m$), Calculate *(08 marks)*

i. reluctance of the magnetic circuit

ii. relative permeability of iron

4. a) Draw shunt generator electric circuit diagram and derive equation for terminal voltage. *(04 marks)*

b) A 230V shunt motor takes 5A at no load. The resistances of the armature and field circuit are 0.25 Ω and 115 Ω respectively. If the motor is loaded so as to carry 40A, determine *(08 marks)*

i. iron and friction losses

ii. efficiency

c) Explain behavior of d.c. motor when motor is suddenly loaded. *(04 marks)*

5. a) By means of simple sketches show the difference between insulated and earthed neutral system With reference to 3-phase power supply. *(05 marks)*

b) Briefly explain with reasons which system is preferred on board ship. *(05 marks)*

c) Draw a diagram showing earth fault lamps on a ships 3-phase electrical system. State how an earth fault is indicated. ***(06 marks)***

6. *a)* Define the followings
   - *i.* Insulator
   - *ii.* Conductor

   (03 marks)

b) What are the physical conditions that would affect an electrical measuring instrument? ***(05 marks)***

c) Name three essential measurements in electrical circuits. ***(05 marks)***

d) You have to measure AC only quantities of a system and there are voltage, current and energy. Which type meter will you select? ***(03 marks)***

7. *a)* State FIVE safety precautions which need to be maintained in Battery Rooms, explaining why they are required. ***(05 marks)***

b) Explain why emergency switch board is provided in Ship board distribution systems stating how it is connected with ship's main supply and Emergency supply, what kind of machinery are provided from this panel, stating 4 examples. ***(05 marks)***

c) Explain with a diagram how uninterrupted power supply is provided with a battery supply while Batteries are being charged with vessel's main and emergency power supply. ***(06 marks)***

8. a) Name two types of losses in a transformer. ***(05 marks)***
   b) Explain, what is an ideal transformer. ***(03 marks)***
   c) Name two applications of transformers. ***(03 marks)***
   d) A transformer has the following properties, ie. number of turns in,

      Primary winding = 4000 turns
      Secondary winding = 800 turns

      A 10 Ω load connected to secondary terminal of the above transformer.
      Calculate the impendence seen by the input terminals. ***(05 marks)***

9. *a)* State THREE protection devices fitted for Generators , briefly explaining why they are required. (Diagrams are not necessary). ***(06 marks)***

b) Explain the basic construction of a Synchronous Generator used on shipboard Electrical Practice. Explain one method of providing field excitation in Synchronous Generators. ***(10 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

Thermodynamics

36

- **Time Allowed - Three Hours**
- **Answer Any Six Questions**
- **Date: 2016.08.31** **Pass Mark 50%**

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

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

a. A quantity of air occupying a volume of $1m^3$ at ***4 bar*** and 150^0C is allowed to expand isentropically to ***1 bar***. Its enthalpy is then raised by ***70 kJ*** by heating at constant pressure. What is the total work during this process? ***(12 Marks)***

b. If the process is to be replaced by a reversible polytropic expansion which will result in the same final state being reached, what index of expansion is required? ***(08 Marks)***

2. In an air-standard cycle heat is supplied at constant volume to raise the temperature of the air from T_1 to T_2. The air then expands isentropically until its temperature falls to T_1; and after this it is returned to its original state by a reversible isothermal compression.

a. Show that the cycle efficiency is; $\eta = 1 - \frac{T_1}{(T_2 - T_1)} \ln \frac{T_2}{T_1}$ ***(10 Marks)***

b. Calculate the efficiency when the pressure rises from ***10*** to ***35 bar*** during the heat supply. ***(10 Marks)***

3. The test bed results for a naturally aspirated, six cylinder, four stroke compression ignition engine with a bore of ***90 mm*** and stroke of ***110 mm*** are as follows

Test speed ***3700 rev/min***
Fuel net calorific value ***42 MJ/kg***
Consumption ***12 kg/h***

Brake load ***0.408 kN*** at radius of ***0.5 m***

Average indicated mean effective pressure for the engine ***7.82 bar***

Determine

a. Indicate power ***(03 marks)***

b. Brake power and mechanical efficiency ***(05 marks)***

c. Brake thermal efficiency and indicated thermal efficiency ***(06 marks)***

d. The brake specific fuel consumption and indicated specific fuel consumption ***(06 marks)***

4. Air at a temperature and pressure of ***300K*** and 1bar is taken through an Otto cycle consisting of the following four non-flow processes:

   a. Isentropic compression through a volumetric compression ratio of ***6***.

   b. Heat addition at constant volume of ***1400kJ/kg*** of air.

   c. Isentropic expansion to the original volume.

   d. Heat rejection at constant volume.

   Calculate the cycle efficiency and mean effective pressure. ***(20 marks)***

5.

a. With the help of ***T-S*** diagram, explain the effect of the following parameters on the efficiency of Rankine vapour power cycle.

   i. Increase of boiler pressure ***(02 Marks)***

   ii. Superheating vapour ***(02 Marks)***

   iii. Decrease of condenser pressure ***(02 Marks)***

b. A steam power plant operates on a Rankine cycle and has a net power output of ***80MW***. Steam enters the high pressure at ***100 bar*** and ***500 ^{0}C*** and the low pressure turbine at ***10 bar*** and ***500^{0}C*** after being reheated. It leaves the low pressure turbine at ***0.1 bar***. Assuming ideal processes, determine:

   i. The quality of steam at exit of low pressure turbine. ***(04 Marks)***

   ii. Thermal Efficiency ***(06 Marks)***

   iii. Mass flow of steam ***(04 Marks)***

6. Diesel cycle has a compression ratio of ***14.5:1***. Compression begins at ***1 bar*** and ***350 K***. The heat added during the constant pressure process is ***1.2 MJ/kg***. Determine

   a. The maximum pressure in the cycle ***(02 marks)***

b. The maximum temperature in the cycle *(02 marks)*

c. Work done per kg of air *(08 marks)*

d. Thermal efficiency *(4 marks)*

e. The mean effective pressure *(4 marks)*

7. In an ideal dual combustion cycle the pressure and temperature at the beginning of the adiabatic compression are ***93 kPa*** and ***24 ^{0}C*** respectively. The volume ratio of the adiabatic compression is ***9:1***. The constant volume heat addition pressure ratio is ***1.5:1*** and constant pressure heat addition volume ratio is ***2:1***. Determine for the cycle

   a. The pressure and temperature at each cardinal points *(12 marks)*

   b. Thermal efficiency *(4 marks)*

   c. The Carnot efficiency within the cycle temperature limits *(4 marks)*

8. ***Refrigerant – 134a*** enters the compressor of a refrigerator as super-heated vapor at ***1.4 bar*** and ***-10 ^{0}C*** at a rate of ***0.12 kg/s***, and it leaves at ***7 bar*** and ***50 ^{0}C***. The refrigerant is cooled in the condenser to saturated liquid at ***26.72 ^{0}C*** and it is throttled to ***1.4 bar***.

   a. Draw the P-H diagram to represent the processes in refrigeration cycle *(4 marks)*

   b. Determine

      i. Condition of the refrigerant at the evaporator inlet *(4 marks)*

      ii. Compressor power *(4 marks)*

      iii. Refrigerating effect in kW *(4 marks)*

      iv. Coefficient of performance *(4 marks)*

   Hint: Use the properties in the table

Pressure, bar	*Saturation temperature, ^{0}C*	*Enthalpy, kJ/kg*		*Entropy, kJ/kg K*	
		h_f	h_g	s_f	s_g
1.4	*-18.80*	*25.77*	*236.04*	*0.1055*	*0.9322*
7	*26.72*	*86.78*	*175.07*	*0.3242*	*0.9080*

Pressure, bar	*temperature,-10 ^{0}C*		*temperature,20 ^{0}C*		*temperature,50^{0}C*	
	h(kJ/kg)	*s(kJ/kg K)*	*h(kJ/kg)*	*s(kJ/kg K)*	*h(kJ/kg)*	*s(kJ/kg K)*
1.4	*243.40*	*0.9606*	*269.13*	*1.0532*	*296.09*	*1.1407*
7	-	-	-	-	*288.35*	*0.9867*

9.

a. ***1 kg*** of steam with ***0.65 dry*** at ***5 bar*** is isothermally expands to pressure ***2 bar*** and then it is compressed under constant pressure to initial volume. Show the process on a ***P-V*** diagram with respect to the saturation lines. ***(8 marks)***

b. Steam is contained in a closed rigid container of ***0.5 m^3***. Initially, the pressure and temperature of the steam are ***1.5 MPa*** and ***250 ^0C***, respectively. The temperature drops to ***100 ^0C*** as a result of heat transfer to surroundings. Determine

i. The mass of steam in the container ***(2 marks)***

ii. The pressure at the final state ***(2 marks)***

iii. Final condition of the steam ***(4 marks)***

iv. The total heat transfer during this process, in kJ ***(4 marks)***

Library

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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 any six questions**

Date: 2016.09.01

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

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1

As per ISM code –

a) Explain why ISM was necessary? (04marks)

b) What is Minor non conformity? (04marks)

c) What is major non conformity? (04marks)

d) What are the certificates/documents issued after the audit? (04marks)

2

With reference to United Nations Convention on Law of the Sea, write short notes on the following

a. The concept on sharing the seas, prior to the original United Nations Convention on Law of the Sea (UNCLOS I) (04 marks)
b. Innocent passage and Right of Innocent Passage (04 marks)
c. The areas a Coastal State could exercise its jurisdiction when a vessel is on passage. (04 marks)
d. International Straight (04 marks)

3 On board sips usage of risk assessment is a general practice.

a) With related to this explain the "risk assessment" (04 marks)

b) Identify the hazards which are involved in overhauling a Fuel Oil Heater of Engine Room. (06 marks)

c) What control measures would you take in order to minimize the risks of the above job to acceptable level (06 marks)

4. SOLAS

a. With reference to SOLAS Chapter II -1 Part B Write in point form the requirement on doors and openings (if any) on Water Tight Bulk head if any when provided (04 marks)

b. With reference to SOLAS Chapter II-2 in order to achieve safety of a ship outline in point form "Fire Safety Objectives" (04 marks)

c. With reference to SOLAS Chapter IX Management for safe operation of ships, note down the purpose of the ISM Code (04 marks)

d. With reference to SOLAS Chapter XI-1 Why is a Continuous Synopsis Record necessary and what ought to be noted in the Continuous Synopsis Record (**Indicate ten items only)** (04 marks)

5.

a) List the 6 Annexes of MARPOL 73/78 (06 Marks)

b) What are the regulations in force for the control of discharge of Oil from ships of over 400 GRT outside Special Areas (05 marks)

c) What are the Special Areas under MARPOL 73/78 – Annex I, as at 1st August 2008. (05 marks)

6. Harmonized System of Survey a Certification (HSSC) is implemented in Sri Lanka from 1st Sept 2005. Explain briefly:

a) Why HSSC was needed (05 marks)

b) What is HSSC and what main convention certificates were brought into HSSC (06 marks)

c) What are the benefits of HSSC to the shipping industry (05 marks)

7.

With reference to MLC

a. Explain in brief what is meant by MLC 2006 (04 marks)
b. Indicate who convened the MLC (02 marks)
c. When did the MLC 2006 enter into force and how many states ratified it (03 marks)
d. What was the intention of the Convention (04 marks)
e. What does DMLC mean (03 marks)

8. Reference to the Ship Energy Efficiency Management Plan (SEEMP)

(a) Briefly explain SEEMP implementation in maritime industry and why it is necessary? (06 marks)

(b)What do you mean by EEDI and EEOI? (04 marks)

(c) Outline possible suggestions, you as a Chief Engineer how to improve Energy Conservation on board (06 marks)

9. With reference to Standard of Training, Certification and Watch keeping for Seafarers STCW and the Code

I.

a. How many Main Parts does the Code comprise of? (02 marks)

b. Are these parts of the code mandatory? (03 marks)

c. Indicate the general areas of (standard of) competence / function (03 marks)

d. Indicate the levels of responsibility and the rank that goes with it (03 marks)

e. Define the term Certificate of Competency (02 marks)

II. Name four of the familiarization training and basic training requirement for all seafarers (03 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

ENGINEERING DRAWING

- **TIME ALLOWED - FOUR HOURS**
- **Answer all questions**

Date: 2016.05.04

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

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Details of a **Plug cock** are shown in the figure. **Plug Cock** is a valve where full flow is through a hole in a tapered plug. Rotating the plug 90° completely stops the flow. By using the **First Angle Projection**, draw the following two views of the assembled **Plug cock**:

(a) A view in **half section** showing the outside view on the left of the vertical centre line and a section on the right hand side, the position of the valve body being similar to that shown on the given detail. The valve should be in **closed** position.

(b) An outside end view projected to the right of (a)

Suitable dimensions should be estimated where not provided. Hidden details are not required in either view. Include on your assembly suitable nuts and bolts and washers where applicable. Between the valve body and cover include a joint ring of thickness 2 mm. The gland should be positioned entering 10 mm into the valve cover.

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 (at least 12 dimensions correctly)	(05 marks)
(e) List of materials of parts	(05 marks)
(f) Title block, projection symbol, lettering	(05 marks)
(g) Final appearance, neatness	(05 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

MARITIME LAW

- **TIME ALLOWED - THREE HOURS**
- **Answer Any Six questions** **Pass mark 50%**

Date: 2016.05.03

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

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1) With reference to IMO conventions explain following terms? *(20 marks)*
   a) Entry in to force criteria.
   b) Force majeure.
   c) Signature, ratification and Acceptance.
   d) Accession.
   e) Tacit approval.

2) As per International convention for management and control of standards of ballast water and sediment
   a) Name 5 viable organisms commonly transmitted *(05 marks)*
   b) Explain ballast water performance standards *(05 marks)*
   c) What are the specific responses and practices under BWM as options for ships? *(05 marks)*
   d) What are the regulations as control measures for ballast water exchange? *(05 marks)*

3) a) With reference to Standard of Training, Certification and Watch keeping for seafarers STCW and the Code
      i. How many main Parts does the code comprise of? *(03 marks)*
      ii. Are these parts of the code mandatory? *(03 marks)*
      iii. Indicate the general areas of competence / functions. *(03 marks)*
      iv. Indicate the levels of responsibility and the ranks that goes with it *(03 marks)*
      v. Define the term Certificate of Competency *(04 marks)*
   b) Name four of the familiarization training and basic training requirement for all seafarers. *(04 marks)*

4) With reference to MARPOL Annex Vi
   a) Explain what are ODS? *(05 marks)*
   b) What is ODP? *(05 marks)*

c) What is global warming potential? *(05 marks)*

d) What do you understand by the comment "GWP of Methane is 72" *(05 marks)*

5) According to international management code(ISM)

a) What are the objectives of the code? *(03 marks)*

b) What are advantages of establishing a safety management system. *(03 marks)*

c) What are the ISM manuals required onboard *(03 marks)*

d) What are the certificates required to carry onboard *(03 marks)*

e) Define following terms

i. Major non conformity *(04 marks)*

ii. Minor non conformity *(04 marks)*

6) As per MARPOL Annex iii Harmful substance carried by sea in packaged form,

a) How those kinds of substances **are classed** under SOLAS chapter vii carriage of Dangerous Goods, **in IMDG code.** *(05 marks)*

b) Explain why marine pollutants are harmful to the aquatic life. *(05 marks)*

c) What are the labeling provisions? *(05 marks)*

d) Define the term Harmful substance as per this annex *(05 marks)*

7) Under load line Convention 1966

a) Define following terms

i. Freeboard *(02 marks)*

ii. Freeboard deck *(02 marks)*

iii. Superstructure *(02 marks)*

iv. Deck line *(02 marks)*

b) Sketch load line marks for a vessel indicating important dimensions *(08 marks)*

c) What could be the reasons that could affect on cancelling of load line certificate issued to a ship? *(04 marks)*

8) a) Explain Harmonized system of survey *(05 marks)*

b) What are the advantages of HSSC *(05 marks)*

c) What is continuous machinery survey *(05 marks)*

d) What are the survey types(HSSC) and describe any two of them *(05 marks)*

9) You have been requested by the Technical Manager of your company to prepare the vessel for a PSC inspection at the next port of call.
List out at least four items from each sections or areas that you would prepare for this inspection.

(20 marks)

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

MATHEMATICS

22

- **TIME ALLOWED - THREE HOURS**
- **Answer any Six questions**

Date: 2016.04.29 **Pass mark 50%**

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

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1.

a. If $\log_b a + \log_c a = 2\log_b a.\log_c a$, show that $a^2 = bc$ (5 marks)

b. If $6\left(9^x\right)+3^x-2=0$, find the real values of x (5 marks)

c. The following values in the table represent the function, $y = \log_{10}(a+bx)$ where a and b are constant.

x	1	2	3	4	5	6
y	0.857	0.924	0.982	1.033	1.079	1.121

i. Plot a graph y vs x (4 marks)

ii. Hence find the constant a and b (6 marks)

2.

a. If the remainder of the division of x^2-2x+a by $x-1$ is equal to the remainder of the division of $2x^2+x-a$ by $2x+1$, find a (4 marks)

b. Resolve in to partial fractions $\dfrac{1+x}{(1+2x)^2(1-x)}$ (4 marks)

c. if α and β are roots of $x^2+7x-3=0$ show that $\alpha^3+\beta^3+7\left(\alpha^2+\beta^2\right)-3(\alpha+\beta)=0$ (6 marks)

d. Solve the inequality $\left|x^2-2x-3\right| \le 3$ (6 marks)

3.

a. If $A=\begin{bmatrix} 2 & 0 \\ -1 & 0 \end{bmatrix}$ and $B=\begin{bmatrix} 1 & 2 \\ 0 & 0 \end{bmatrix}$, show that

i. $AB=\begin{bmatrix} 2 & 4 \\ -1 & -2 \end{bmatrix}$ and $BA=\begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}$ (6 marks)

ii. $(AB)^T = B^T A^T$ and $(BA)^T = A^T B^T$ (6 marks)

b. Show that $\begin{vmatrix} 0 & b & c \\ b & 0 & a \\ c & a & 0 \end{vmatrix} = 2abc$ (8 marks)

4.

a. Find the roots of $z^2 + z + 1 = 0$ and hence show that the sum of the roots equals to - 1 and the product of the roots equals 1. (6 marks)

b. Find the roots of 1 + i (4 marks)

c. Represents the following complex numbers on a Argand diagram 3 + 2i, 1/(3 + 2i) and (1 - i)/(1 + i) and also find the modulus and argument of each number. (10 marks)

5.

a. Prove that $\text{Sin } 3\theta = 3Sin\theta - 4\ Sin^3\theta$. Obtain expression for $Cos\ 3\theta$ (6 Marks)

b. Find the solutions of the equation $\text{Cos } 2\alpha + \text{Cos}\alpha + 1 = 0$ between 0 and 2π radians. (6 Marks)

c. From a point A on level ground, the angles of elevation of the top D and bottom B of a flagpole situated on the top of a hill are measured as 48^0 and 40^0. Find the height of the hill if the height of the flagpole is 120 ft. (8 Marks)

6. An open topped metal tank with rectangular sides has a square base of side x meters. The internal surface area is 200 m^2.

a. Show that the volume of the tank is given by function V where : $V = 50x - \frac{x^3}{4}$ (4 marks)

b. Using differential calculus, calculate the value of x such that the volume of the tank is a maximum (8 marks)

c. Calculate the maximum volume of the tank (4 marks)

d. The tank is filled with the rate of 20 – 3t m^3/s find the time taken to fill the maximum volume of the tank (4 marks)