MARINE DIESEL ENGINEERING

Attempt ALL questions
Marks for each part question are shown in brackets

1. With reference to diesel engines, explain EACH of the following terms:

   (a) top dead centre; (1)

   (b) bottom dead centre; (1)

   (c) piston stroke; (2)

   (d) swept volume; (2)

   (e) clearance volume; (2)

   (f) compression ratio. (2)

2. With reference to diesel engine turbocharging:

   (a) explain why the charge air from a turbocharger is cooled before entering the engine cylinder; (4)

   (b) explain the possible effects of excessively cooled charge air; (3)

   (c) explain the possible effects of inadequately cooled charge air. (3)

3. (a) State THREE desirable properties of piston rings. (3) Look at again

   (b) State the materials commonly used for piston rings. (2)

   (c) Sketch THREE different types of piston ring ends. (3)

   (d) Explain why piston ring end clearance is necessary. (2)

4. (a) Sketch a section through a crankcase relief valve, labelling the MAIN components. (5)

   (b) Explain the conditions which must be present for a crankcase explosion to occur. (5)

5. With reference to diesel engine fuel:

   (a) explain the meaning of the term *microbial contamination*; (1)

   (b) describe the possible problems the engine may encounter if the fuel received is contaminated with microbes; (4)

   (c) explain how *microbial contamination* can be avoided; (3)

   (d) explain the actions to be taken if *microbial contamination* is severe. (2)

6. Describe, with the aid of a sketch, the operation of a centrifugal type lubricating oil filter, labelling the MAIN components. (10)

7. (a) State FOUR conditions for the fresh water cooling system treatment program to be effective. (4)

   (b) State the function of the inhibitor used in fresh water cooling treatment. (3)

   (c) Explain the safety considerations needed when handling the inhibitors. (3)

8. (a) Describe, with the aid of a sketch, the construction of a plate type heat exchanger. (7)

   (b) State THREE advantages of the plate types, compared with the tube type heat exchanger. (3)

9. (a) Describe how to calibrate a diesel engine cylinder liner, already removed from the engine. (6)

   (b) State the precautions that should be taken during initial startup when putting a new liner into service. (4)

10. (a) Sketch a block diagram of a lubricating oil system suitable for use with a reduction gearing, including all the protective devices. (5)

    (b) State the engineering purpose/function of EACH item in the system sketched in part (a). (5)

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(c) piston stroke; (2)

(d) swept volume; (2)

(e) clearance volume; (2)

(f) compression ratio. (2)

(a) Top Dead Centre (TDC) (1 mark)

- The highest point reached by the piston in the cylinder during its movement.
- At this position, the cylinder volume is at its **minimum (clearance volume only)**.

(b) Bottom Dead Centre (BDC) (1 mark)

- The lowest point reached by the piston in the cylinder.
- At this position, the cylinder volume is at its **maximum (swept + clearance volume)**.

(c) Piston Stroke (2 marks)

- The **linear distance** the piston travels between **TDC and BDC**.
- Important for calculating **engine displacement, swept volume, and mean piston speed**.

(d) Swept Volume (2 marks)

- The volume displaced by the piston as it moves from TDC to BDC.
- Formula:

$$V_s = \frac{\pi}{4} \times D^2 \times L$$

- where D = cylinder bore, L = stroke.

- Represents the **working volume** where combustion gases expand.

(e) Clearance Volume (2 marks)

- The volume of space remaining in the cylinder when the piston is at TDC.
- Necessary to prevent piston-to-head contact and provides space for **valves/fuel injection and combustion**.

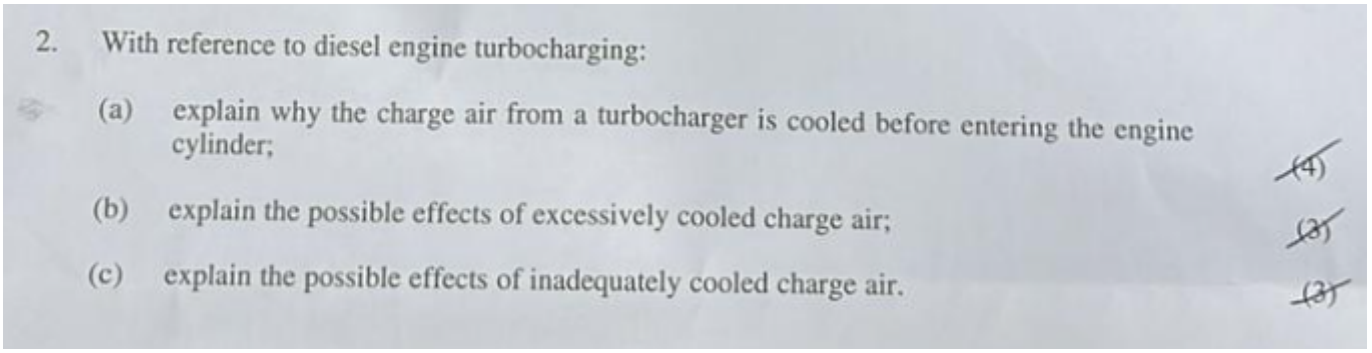
(f) Compression Ratio (2 marks)

- The ratio of the cylinder volume at BDC to the volume at TDC.
- Formula:

$$CR = \frac{V_s + V_c}{V_c}$$

where V_s = swept volume, V_c = clearance volume.

Affects **thermal efficiency and ignition**: higher compression ratio = higher efficiency, but risk of knocking.



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(b) explain the possible effects of excessively cooled charge air; ~~(3)~~

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(a) Why the charge air from a turbocharger is cooled before entering the engine cylinder (4 marks)

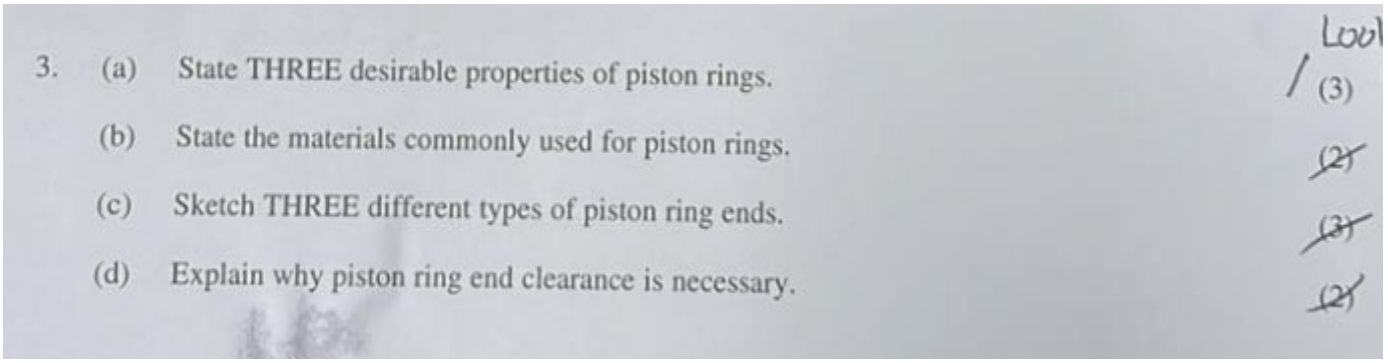
- Compression by the turbocharger raises **temperature of the charge air**.
- Hot air is less dense, reducing the **mass of air** that can enter the cylinder.
- By cooling the charge air in a **charge air cooler (intercooler)**, its density increases → **more oxygen per cycle**, better combustion.
- Cooling also reduces **thermal loading of engine components**, improves efficiency, lowers fuel consumption, and reduces NOx emissions.

(b) Possible effects of excessively cooled charge air (3 marks)

- Temperature may fall **below dew point**, causing **condensation of water** in the air → risk of corrosion and erosion in cylinders.
- Poor fuel atomisation and ignition delay → **incomplete combustion, white smoke**.
- Risk of **cold corrosion** on liners and exhaust system.

(c) Possible effects of inadequately cooled charge air (3 marks)

- Reduced air density → **less oxygen per cycle**, poor combustion.
- Higher cylinder temperatures → increased risk of **knocking, thermal stress, and piston/valve overheating**.
- Increased **NOx emissions** and loss of efficiency/power.


3. (a) State THREE desirable properties of piston rings. (3)
(b) State the materials commonly used for piston rings. (2)
(c) Sketch THREE different types of piston ring ends. (3)
(d) Explain why piston ring end clearance is necessary. (2)

(a) Three desirable properties of piston rings (3 marks)

1. High **wear resistance** to withstand friction against the liner.
2. Good **elasticity/springiness** to maintain a gas-tight seal.
3. Ability to **withstand high temperatures and pressures** without distortion.

(Other acceptable: corrosion resistance, low coefficient of friction, good heat conductivity.)

(b) Materials commonly used for piston rings (2 marks)

- **Alloy cast iron** (good wear resistance, retains elasticity).
- **Steel** (for high-strength, high-performance applications).
- Often surface-treated or coated with **chrome, molybdenum, or ceramic materials** for reduced wear and friction.

(c) Sketch three different types of piston ring ends (3 marks)

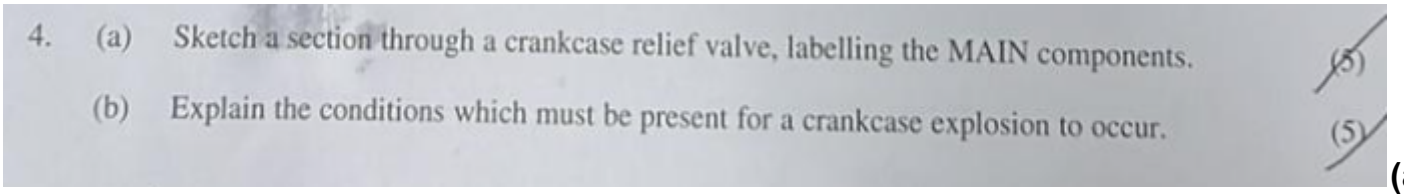
(You would draw these in the exam — simple line sketches with labels are enough)

1. **Butt joint** (square cut ends).
2. **Step joint** (ends overlap in a step).
3. **Scarf joint** (ends cut diagonally at an angle).

(Each sketch should show the shape of the ring end in cross-section.)

(d) Why piston ring end clearance is necessary (2 marks)

- To allow for **thermal expansion** of the piston ring during operation.
- Without clearance, the ring ends would butt together when hot, causing **seizure, scuffing, or cylinder liner damage**.
- Correct clearance ensures both sealing and safe expansion.


4. (a) Sketch a section through a crankcase relief valve, labelling the MAIN components. (5)

(b) Explain the conditions which must be present for a crankcase explosion to occur. (5)

(a) Sketch a section through a crankcase relief valve, labelling the MAIN components (5 marks)

Description of Sketch (exam-style):

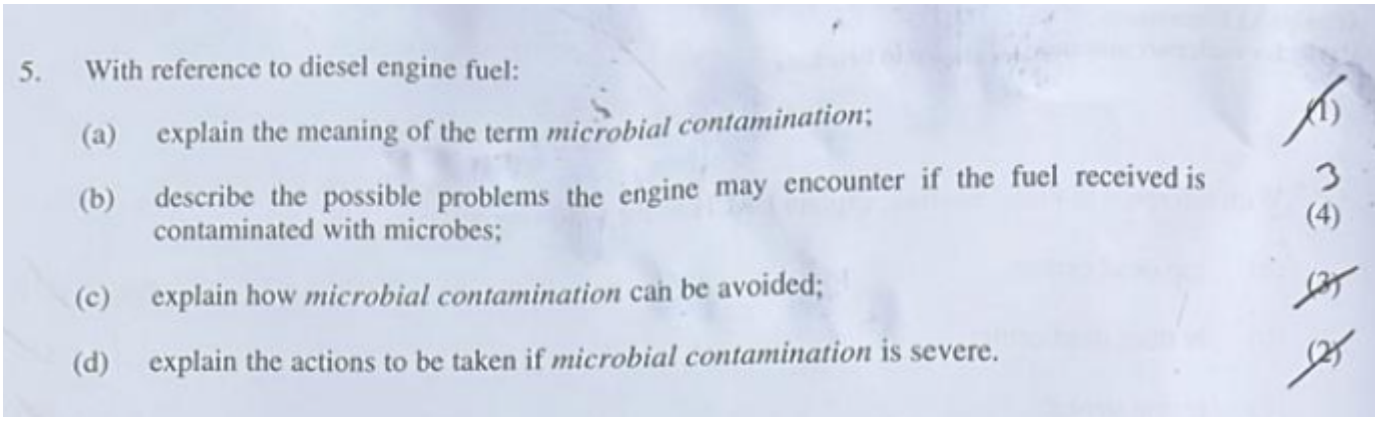
- A circular valve fitted on crankcase doors.
- Main components:
    1. **Valve body/housing** – fitted to the crankcase door.
    2. **Valve disc/plate** – normally held closed against a seat.
    3. **Spring** – holds the disc shut under normal pressure.
    4. **Flame arrestor (metal mesh)** – prevents flame from passing into engine room.
    5. **Protective cover/deflector** – directs gas away from personnel.

(You would draw a vertical section showing the disc on a spring, the seat, flame trap mesh, and the deflector cover.)

(b) Conditions which must be present for a crankcase explosion to occur (5 marks)

1. **Presence of oil mist** in the crankcase (from overheated bearings, hot spots, or splashing).
2. **Sufficient concentration** of oil mist mixed with air to form an explosive mixture.
3. A **source of ignition**, usually a hot spot such as an overheated bearing, cracked piston, or friction surface.

4. **Confined space** (crankcase enclosure) to allow pressure to build.
5. Time for the explosive range to be reached before ignition.



5. With reference to diesel engine fuel:

(a) explain the meaning of the term *microbial contamination*; (1)

(b) describe the possible problems the engine may encounter if the fuel received is contaminated with microbes; 3 (4)

(c) explain how *microbial contamination* can be avoided; (2)

(d) explain the actions to be taken if *microbial contamination* is severe. (2)

(a) Meaning of the term *microbial contamination* (1 mark)

- The presence and growth of **micro-organisms** (bacteria, fungi, yeasts) in diesel fuel, usually at the **fuel–water interface** where water in the tank provides a breeding ground.

(b) Possible problems if fuel is contaminated with microbes (4 marks)

1. Formation of **sludge and biomass** → blocks filters and fuel lines.
2. Production of **acids** → leads to fuel system **corrosion**.
3. **Poor combustion** due to degraded fuel quality.
4. Risk of **engine failure or stoppage** from fuel starvation or injector fouling.

(c) How microbial contamination can be avoided (2 marks)

- **Keep tanks free of water** (regular draining of settling/service tanks).
- Use of **biocides** to kill microbes.
- Maintain **good fuel handling practices** (clean tanks, proper storage, regular inspections).

(d) Actions to be taken if microbial contamination is severe (3 marks)

1. **Dose tanks with biocides** to kill microbial growth.
2. **Clean and flush tanks** to remove sludge and residues.
3. **Replace clogged filters and clean fuel lines**.
4. Inform **supplier** if contamination was received with fuel bunkers.

6. Describe, with the aid of a sketch, the operation of a centrifugal type lubricating oil filter, labelling the MAIN components. (10)

Description & Main Components

A centrifugal type lubricating oil filter removes impurities from lubricating oil by centrifugal force rather than paper/mesh filtration.

Main components to label in sketch:

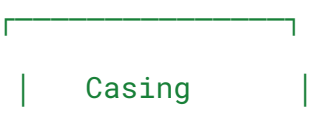
1. Filter casing/housing.
2. Oil inlet and outlet connections.
3. Rotor (bowl).
4. Jet nozzles (at base of rotor).
5. Shaft/spindle (rotor mounted on it).
6. Sludge collection space inside the rotor.
7. Drive system (oil pressure drives rotor).

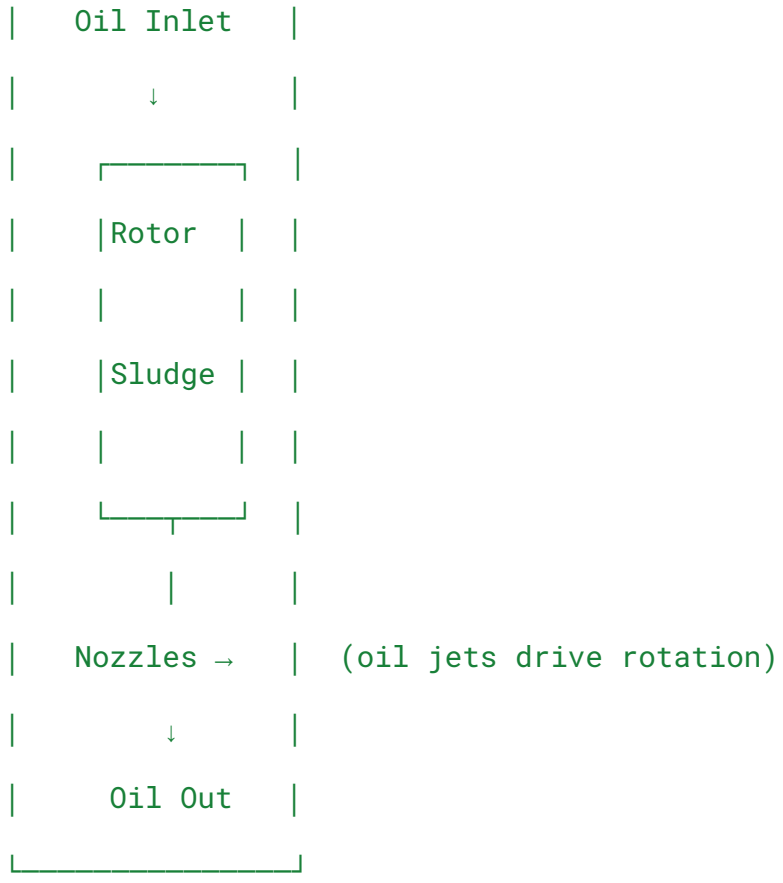
Operation

1. **Lubricating oil under pressure** enters the filter casing.
2. Oil flows into the **rotor**, which is mounted on a vertical spindle.
3. The oil passes through **two small opposing nozzles** at the base of the rotor.
4. As oil jets out, a **reaction force causes the rotor to spin** at high speed (6,000–8,000 rpm).
5. Due to the centrifugal force, **solid impurities and sludge are thrown outwards** against the rotor wall and collect inside the rotor.
6. The **clean oil** exits through the rotor centre and flows back to the lubricating system.
7. During maintenance, the rotor is opened and the collected sludge is manually removed.

Sketch (exam-style)

(Your drawing should show a vertical section through the filter with labels)





Labels: casing, oil inlet/outlet, rotor, sludge space, nozzles, spindle.

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7. (a) State FOUR conditions for the fresh water cooling system treatment program to be effective. (4)

(b) State the function of the inhibitor used in fresh water cooling treatment. (3)

(c) Explain the safety considerations needed when handling the inhibitors. (3)

(a) Four conditions for the fresh water cooling system treatment program to be effective (4 marks)

1. Correct **dosage of inhibitor** must be maintained (too little is ineffective, too much is wasteful/corrosive).
2. **Regular monitoring** of inhibitor concentration, pH, and water quality.
3. **No contamination** from seawater, oil, or dirt.
4. The **system must be kept clean**, with proper flushing and removal of scale/sludge.

(Other acceptable: circulation of water throughout the system to distribute chemicals; correct operating temperature range; avoiding stagnant areas.)

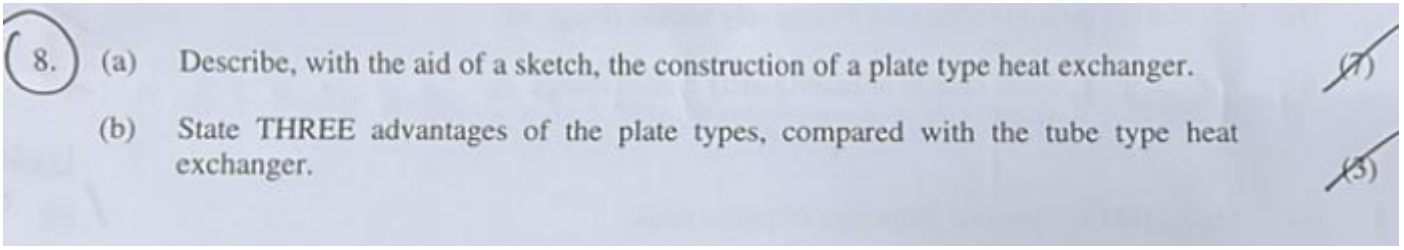
(b) Function of the inhibitor used in fresh water cooling treatment (3 marks)

- To **prevent corrosion** of engine components (e.g., cylinder liners, water jackets, heat exchangers).
- To **prevent scale formation** by controlling hardness and deposits.
- To act as a **biocide**, reducing microbial growth (algae, bacteria) in the cooling system.

(c) Safety considerations when handling inhibitors (3 marks)

1. Wear **appropriate PPE** (gloves, goggles, protective clothing) to avoid skin/eye contact.
2. Ensure **good ventilation** when handling, as fumes may be harmful.
3. Follow **manufacturer's instructions** – avoid mixing with incompatible chemicals and store securely in labelled containers.

✅ **Model Answer Recap:**
(a) Correct dosage, regular monitoring, cleanliness, no contamination.
(b) Inhibitor prevents corrosion, scale, microbial growth.
(c) PPE, ventilation, follow safe handling and storage practices.



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(b) State THREE advantages of the plate types, compared with the tube type heat exchanger. (3)

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A plate type heat exchanger is made up of a series of **thin, corrugated metal plates** (usually stainless steel) clamped together in a frame.

- Each plate has **gaskets** or **brazed joints** which direct the flow of two fluids (hot and cold) into alternate channels.
- The plates are pressed with a corrugated pattern to increase **surface area** and promote turbulence, improving heat transfer.
- The fluids pass on opposite sides of each plate in a **counter-flow arrangement**, which ensures maximum thermal efficiency.
- The frame consists of a **fixed head** (stationary plate) and a **movable follower** (clamping plate), tightened with bolts to compress the plate pack.

Sketch (simplified):

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| Hot fluid in → | || | | || | | || | | || | → out

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| Cold fluid in →|| | | || | | || | | || | | → out

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(Each | | represents a plate, with alternating hot/cold fluid channels.)

(b) State THREE advantages of the plate types, compared with the tube type heat exchanger. (3)

1. **High thermal efficiency** – Large surface area per unit volume due to thin plates and turbulence created by corrugations.
2. **Compact size and lightweight** – Requires less space than tube type exchangers for the same duty.
3. **Ease of cleaning and maintenance** – Plates can be dismantled, inspected, and cleaned individually.

(Other acceptable answers: ability to expand capacity by adding more plates; lower fouling tendency due to turbulence; lower approach temperature possible.)

9. (a) Describe how to calibrate a diesel engine cylinder liner, already removed from the engine. (6)

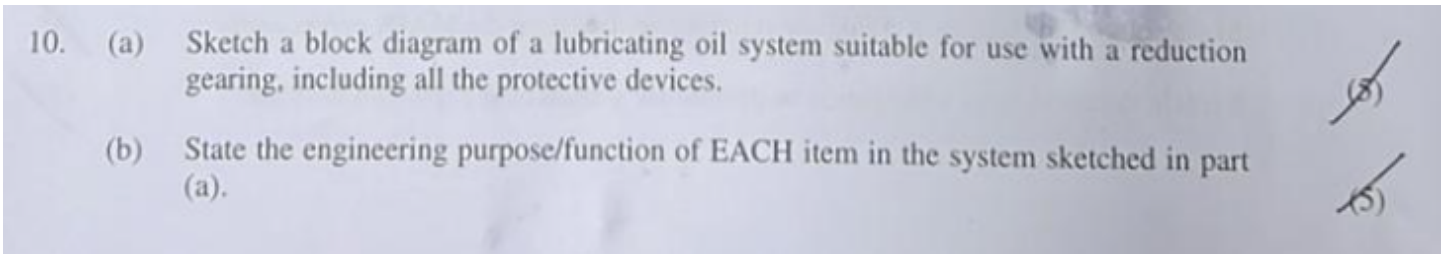
(b) State the precautions that should be taken during initial startup when putting a new liner into service. (4)

(a) Describe how to calibrate a diesel engine cylinder liner, already removed from the engine. (6)

1. ***Clean the liner thoroughly*** *– Remove all carbon deposits, rust, and oil before measurement.*
2. ***Set the liner on a stable surface*** *– Ensure it is upright and supported to prevent distortion.*
3. ***Use a calibrated internal micrometer or bore gauge*** *– Take measurements at specified points.*
4. ***Measure at three levels*** *– Top, middle, and bottom of the liner (to check for wear distribution).*
5. ***Measure in two directions at each level*** *– At right angles (fore-aft and athwartships) to detect ovality.*
6. ***Compare results with manufacturer's tolerances*** *– Determine if the liner is within limits or needs replacement/re-machining.*

(b) State the precautions that should be taken during initial startup when putting a new liner into service. (4)

1. ***Ensure correct lubrication*** *– Pre-lubricate liner walls with oil before fitting pistons.*
2. ***Check proper cooling water circulation*** *– Prevents thermal shock and distortion.*
3. ***Run the engine at low load initially*** *– Allows gradual bedding-in of piston rings and liner surface.*
4. ***Monitor closely*** *– Keep watch on exhaust temperatures, cooling water outlet, and lubricating oil pressure/temperature for abnormalities.*



10. (a) Sketch a block diagram of a lubricating oil system suitable for use with a reduction gearing, including all the protective devices. (5)

(b) State the engineering purpose/function of EACH item in the system sketched in part (a). (5)

(a) Sketch a block diagram of a lubricating oil system suitable for use with reduction gearing, including all the protective devices. (5)

- *A typical LO system includes the following blocks (can be drawn in sequence):*

1. ***LO Sump (Tank/Drain)***
    - *Stores oil supply.*
2. ***LO Pump (Main + Standby / Emergency)***
    - *Supplies oil under pressure to the system.*
3. ***Suction Strainer***
    - *Removes large particles before pump.*
4. ***Cooler (Shell-and-tube type, using sea water or fresh water)***
    - *Controls oil temperature.*
5. ***Filter (Duplex / Auto-cleaning)***
    - *Removes fine contaminants.*
6. ***Pressure Relief Valve***
    - *Protects system from overpressure.*
7. ***Pressure Control / Alarm Devices***
    - *Low-pressure alarm, low-level alarm, high-temperature alarm.*
8. ***Distribution Manifold to Reduction Gearing Bearings and Gear Meshes***

- *Supplies clean, cooled oil to gears and bearings.*

9. ***Return Lines back to Sump***
    - *Oil drains back after circulation.*

(b) State the engineering purpose/function of EACH item in the system sketched in part (a). (5)

1. ***Sump*** *– Collects oil and allows sedimentation of heavy particles.*
2. ***Pump(s)*** *– Maintains continuous oil flow at correct pressure. Standby ensures reliability.*
3. ***Strainer*** *– Protects pump from damage by debris.*
4. ***Cooler*** *– Maintains oil temperature within limits to preserve viscosity.*
5. ***Filter*** *– Removes dirt, wear particles, and sludge to prevent bearing/gear damage.*
6. ***Pressure Relief Valve*** *– Prevents excessive pressure that could damage components.*
7. ***Alarms/Protective Devices*** *– Warn operator of unsafe conditions (low LO pressure, high LO temp, low sump level).*
8. ***Distribution Manifold*** *– Delivers LO to bearings, gears, and clutches at correct pressure and flow.*
9. ***Return System*** *– Ensures oil is collected and reused, completing the circulation loop.*