

① ✓ With reference to butterfly valves:

(a) ✓ describe their construction; (5)

(b) ✓ state the advantages and disadvantages when compared to a gate valve. (5)

(a)

Construction of a butterfly valve (5 marks)

A butterfly valve consists of a **circular disc (butterfly)** mounted on a **shaft** within a **valve body**. The disc is positioned in the flow path and rotates about the shaft to control flow. The shaft is connected to an **actuator or hand lever**, allowing the disc to be turned through 90° . The valve includes **seals (seat/liner)** around the body to ensure tight shut-off, and **bearings** to support smooth rotation of the shaft. When the disc is parallel to the flow, the valve is open; when perpendicular, it is closed.

(b) Advantages and disadvantages compared to a gate valve (5 marks)

Advantages:

- **Quick operation** (quarter-turn opening/closing).
- **Compact and lightweight** design.
- **Lower cost** and simpler construction.
- Suitable for **throttling/flow control**.

Disadvantages:

- **Higher flow resistance** (disc remains in flow path).
- **Not as tight a seal** as a gate valve in some applications.
- **Wear of seals** due to constant contact with flow.
- Not ideal for **high-pressure applications** compared to gate valves.

② (a) ✓ Explain how cavitation damage occurs within a pump. (6)

(b) ✓ State, with reasons, TWO operational causes of increased cavitation within a pump. (4)

(a)

How cavitation damage occurs within a pump (6 marks)

Cavitation occurs when the **local pressure of the liquid falls below its vapour pressure**, causing the formation of **vapour bubbles** within the fluid, typically at the pump inlet or impeller eye. As the fluid moves into regions of higher pressure inside the pump, these bubbles **collapse violently (implode)**.

This collapse produces **shock waves and high localised pressures**, which strike nearby metal surfaces such as the **impeller and casing**. Over time, this leads to **pitting, erosion, noise**,

vibration, and eventual damage to the pump components, reducing efficiency and potentially causing failure.

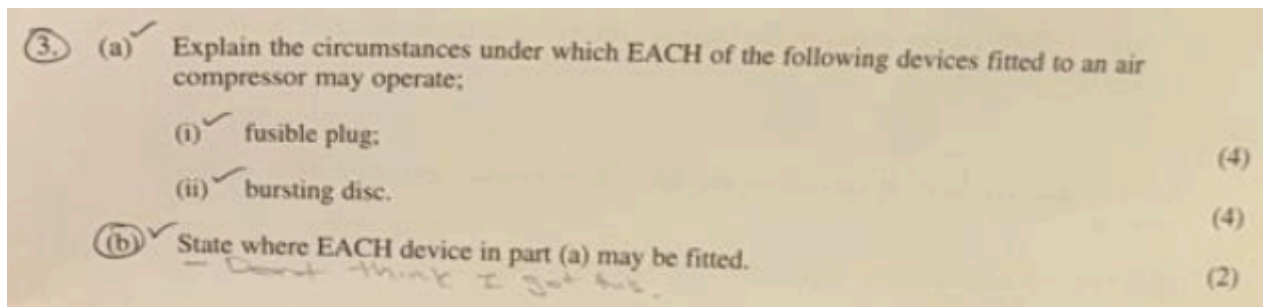
(b) TWO operational causes of increased cavitation (4 marks)

1. Insufficient suction head (low NPSH)

→ Caused by low tank level, high suction lift, or restrictions in suction line, leading to pressure dropping below vapour pressure.

2. Excessive pump speed or flow rate

→ Increases velocity at the inlet, reducing pressure and promoting bubble formation.



(a)

Circumstances under which devices operate (4 marks)

(i) Fusible plug

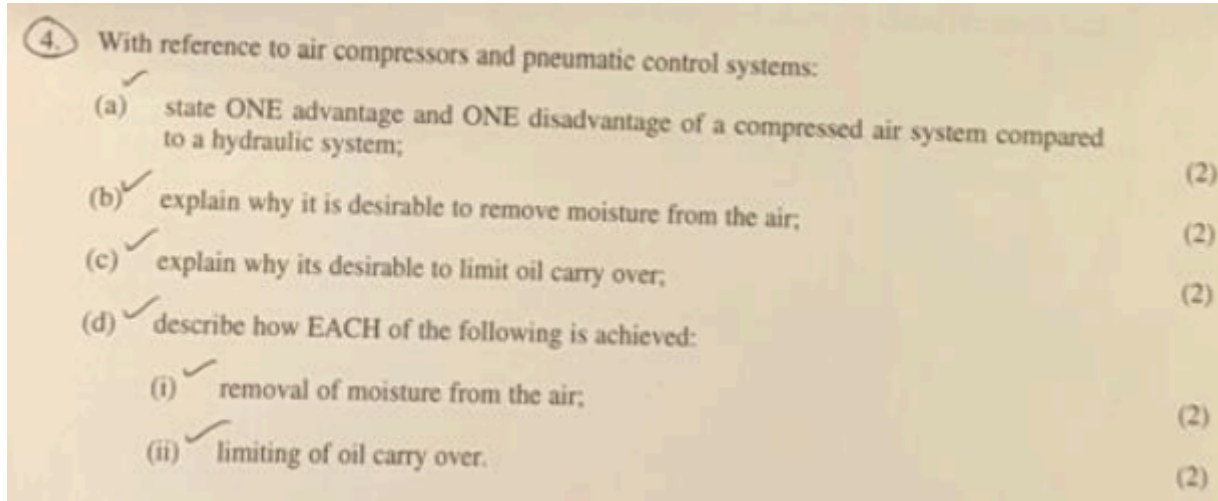
- Operates when **temperature rises above a preset limit**.
- Typically melts due to **overheating** (e.g. poor cooling, fire, or excessive discharge temperature), allowing pressure to be released.

(ii) Bursting disc

- Operates when **pressure exceeds a predetermined limit**.
- The disc ruptures suddenly due to **overpressure**, providing immediate pressure relief.

(b) Where each device is fitted (2 marks)

- **Fusible plug** → fitted on **compressor cylinder head or discharge side** (where overheating may occur).
- **Bursting disc** → fitted on **intercoolers, aftercoolers, or air receiver** (to protect against overpressure).



(a) ONE advantage and ONE disadvantage of compressed air vs hydraulic systems (2 marks)

- **Advantage:**
→ Compressed air systems are **clean and safe** (no risk of oil leakage or fire hazard).
 - **Disadvantage:**
→ Air is **compressible**, leading to **less precise control and lower efficiency**.
-

(b) Why it is desirable to remove moisture from the air (2 marks)

- Prevents **corrosion** in pipelines and equipment.
 - Avoids **freezing and blockage** in valves and control systems.
-

(c) Why it is desirable to limit oil carry-over (2 marks)

- Prevents **contamination of pneumatic equipment and control systems**.
 - Reduces risk of **carbon deposits and possible fire/explosion** in air systems.
-

(d) How each is achieved (4 marks)

(i) Removal of moisture from air:

- Use of **aftercoolers** to condense water vapour.
- **Air dryers and moisture separators** to remove condensed water.

(ii) Limiting oil carry-over:

- Use of **oil separators** after the compressor.
- Proper **maintenance of compressor and filters**.

5. Sketch a valve operated, rotary vane steering gear, showing the hydraulic system from the directional valve to the rotary vane unit.

(10)

Valve-operated rotary vane steering gear (10 marks)

Description:

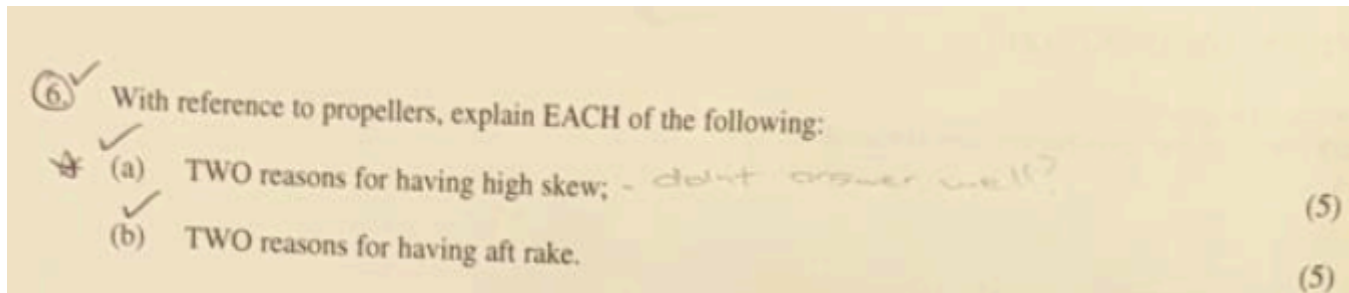
In a rotary vane steering gear, hydraulic oil from the **pump** is directed by a **directional control valve** to either side of the **rotary vane unit**. The unit consists of a **rotor with fixed vanes** inside a casing.

When oil is supplied to one side (e.g. Port A), pressure acts on the vanes, causing the rotor to **rotate**, which turns the **rudder stock**. Oil from the opposite side is returned to the tank. Reversing the valve directs oil to the other side (Port B), rotating the rudder in the opposite direction.

The system provides **smooth, controlled movement of the rudder**, and relief valves are usually fitted to prevent overpressure.

Main components to label:

- Hydraulic pump
- Directional control valve
- Pressure lines (Port A and Port B)
- Rotary vane unit (rotor and vanes)
- Return line
- Oil tank/reservoir



TWO reasons for having high skew (5 marks)

1. **Reduction of vibration and noise**
→ High skew spreads the blade loading more evenly as it passes through uneven wake, reducing pressure pulses on the hull.
2. **Improved cavitation performance**
→ Delays and reduces cavitation by distributing load along the blade, leading to less erosion and smoother operation.

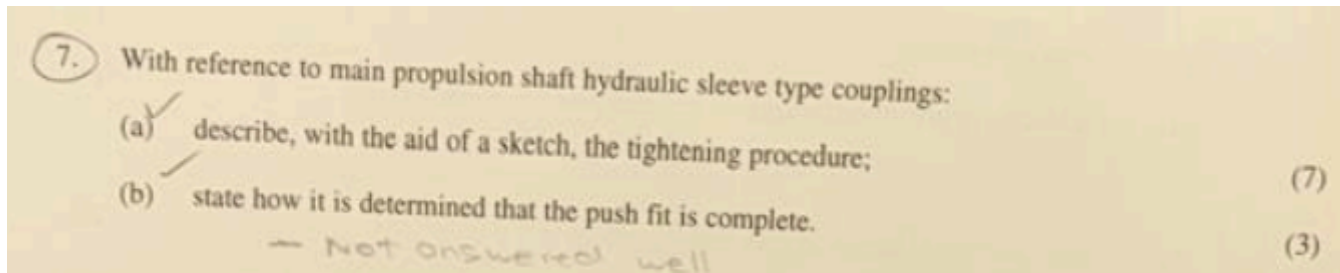
(b) TWO reasons for having aft rake (5 marks)

1. Reduces risk of damage from debris or grounding

→ Aft rake moves blade tips away from the hull and seabed, improving clearance.

2. Improves flow into the propeller

→ Provides better interaction with the wake field, improving efficiency and reducing vibration.

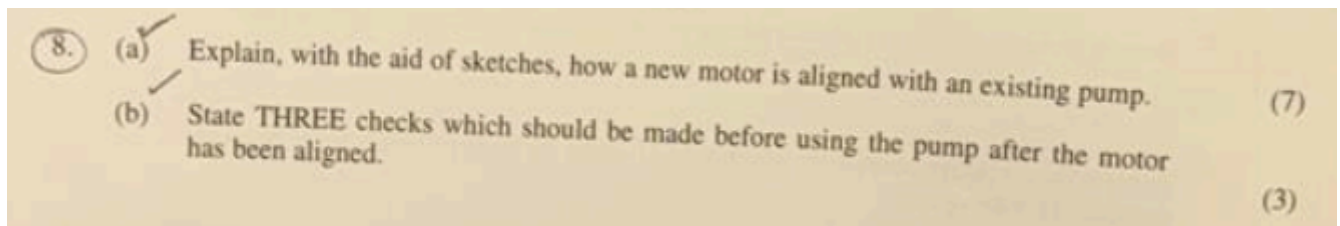


Procedure:

1. **Clean and inspect mating surfaces** (shaft and coupling bore).
2. Position the coupling onto the shaft to the **initial location**.
3. Connect a **high-pressure hydraulic pump** to the oil injection ports.
4. **Inject high-pressure oil** between the shaft and sleeve to expand the coupling and reduce friction.
5. Apply **axial force using jacking gear** to push the coupling along the shaft.
6. Continue oil injection and jacking until the coupling reaches the **specified axial position**.
7. Release hydraulic pressure, allowing the sleeve to **shrink and grip the shaft** (interference fit).

(b) How it is determined that the push fit is complete (3 marks)

- The coupling has reached the **correct axial position** (checked against reference marks or measurements).
- The **specified hydraulic pressure** has been achieved during fitting.
- **No further axial movement** occurs when pressure is applied, indicating full seating



(a)

Alignment of a new motor with an existing pump (7 marks)

1. Rough alignment (straight edge)

Motor Shaft ——— Coupling ——— Pump Shaft

| |

————— Straight Edge —————

- Use a **straight edge** across the coupling halves.
- Adjust motor position until shafts are approximately in line.

2. Angular alignment (face gap check)

Coupling Faces

| gap |

| |

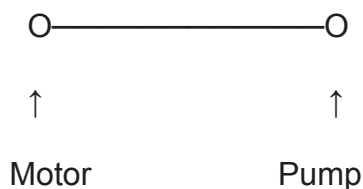
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(Check at top, bottom, left, right)

- Measure gap between coupling faces at multiple points.
 - Adjust until the **gap is equal all around** → removes angular misalignment.
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3. Parallel alignment (dial gauge method)

Dial Gauge on Coupling Rim



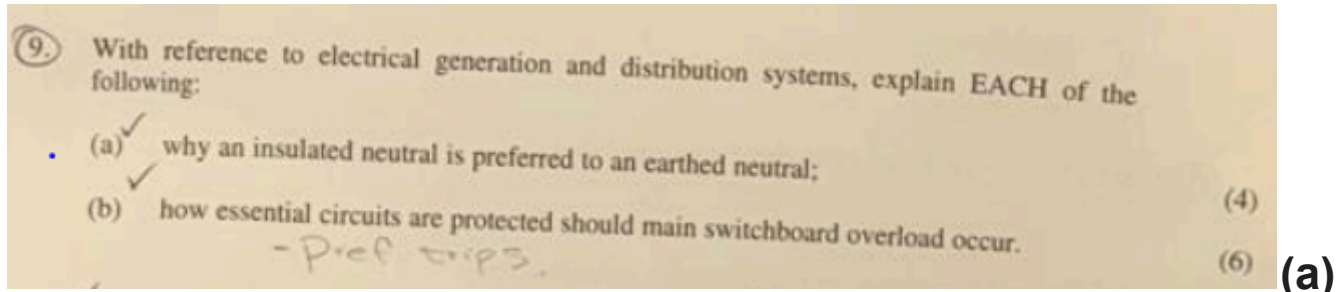
- Use a **dial indicator** on the coupling rim.
 - Rotate shafts and observe readings.
 - Adjust motor sideways and vertically until readings are equal → shafts are parallel.
-

Procedure summary:

- Adjust motor using **shims (vertical)** and **sideways movement (horizontal)**.
 - Tighten holding-down bolts gradually and **recheck alignment**.
 - Final alignment must be within acceptable tolerances.
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(b) THREE checks before using the pump (3 marks)

1. **Recheck alignment after tightening**
→ Ensure no movement occurred during bolting.
2. **Check coupling and guards fitted correctly**
→ Ensure safe operation.
3. **Run test and monitor for vibration, noise, and temperature**
→ Confirm smooth and correct operation.

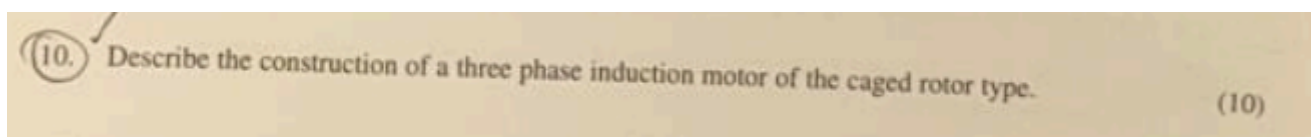


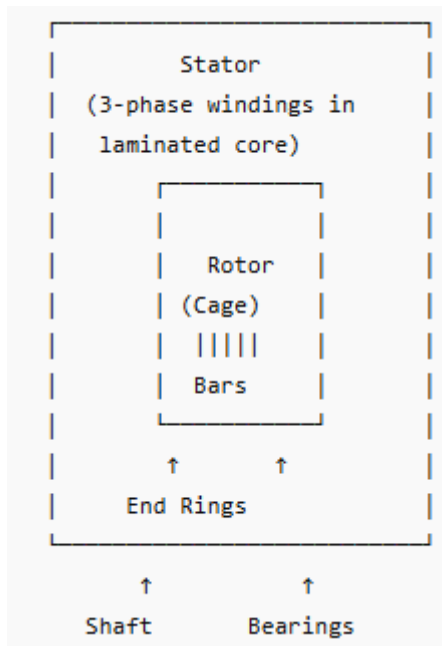
Why an insulated neutral is preferred to an earthed neutral (4 marks)

- **Continuity of supply is maintained**
→ A single earth fault does not cause immediate tripping, allowing essential systems to keep running.
- **Improved safety for ship operation**
→ Fault can be located and corrected without loss of power.
- **Reduced risk of arcing and damage**
→ Fault current is limited compared to an earthed system.
- **Earth fault monitoring can be used**
→ Insulation monitoring devices give early warning of faults.

(b) How essential circuits are protected during main switchboard overload (6 marks)

- **Load shedding systems** automatically disconnect **non-essential loads**.
- Priority is given to **essential services** (e.g. steering gear, navigation systems).
- **Circuit breakers** are arranged with **discrimination/selectivity**, so only the affected circuits trip.
- **Generator protection systems** prevent overload by reducing load or tripping non-essential consumers.
- **Automatic start of standby generator** may occur to share load.
- Ensures **essential circuits remain energised** while protecting the system from total blackout.





Description:

A three-phase induction motor consists of a **stator** and a **rotor** enclosed within a robust frame.

Stator:

- Made of a **laminated steel core** to reduce eddy current losses.
- Contains **three-phase windings** placed in slots around the inner circumference.
- When supplied with three-phase AC, it produces a **rotating magnetic field**.

Rotor (squirrel cage type):

- Consists of a laminated core with **conducting bars** (usually aluminium or copper) embedded in slots.
- The bars are **short-circuited at both ends by end rings**, forming a “cage”.
- No external electrical connection is required.

Other components:

- **Shaft** → transmits mechanical output.
- **Bearings** → support smooth rotation.
- **Air gap** → small clearance between stator and rotor.
- **Cooling fan** (often fitted) → removes heat.
- **Casing/frame** → provides protection and structural support.

Working principle (brief mention for extra marks):

The rotating magnetic field in the stator induces currents in the rotor bars, producing a **magnetic field in the rotor**, which interacts with the stator field to produce **torque**, causing the rotor to rotate.

