Competency Unit Module MARN008

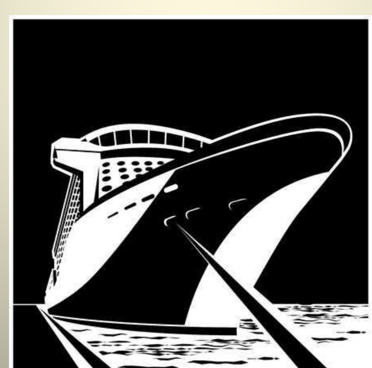
Perform seamanship operations onboard a vessel

Module Syllabus

- ❑ **Mooring Skills**
- ❑ **Ropes, Knots and Splices**
- ❑ **Lifting Equipment and Hydraulics**
- ❑ **Anchor Systems**
- ❑ **Refuelling**
- ❑ **Pollution**
- ❑ **Stability**

1

MOORING SKILLS



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Mooring Skills

On completing this session

You will

- ✓ Know how to care for mooring lines.
- ✓ Describe the safe use of mooring lines.
- ✓ Be able to name the most common mooring lines.
- ✓ Explain the purpose of the more common mooring lines.
- ✓ Describe how you could use the various lines to secure your vessel.
- ✓ Outline the purpose of, and how to, "Dip The Eye"
- ✓ Explain how to safely connect shore based power leads and other umbilicals.

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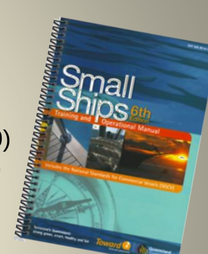
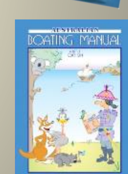
Mooring Skills

Recommended Study Reference



Small Ships Training and Operational Manual – Edition 6
Maritime Safety Queensland
Chapter 23 – Mooring lines & fittings (pg 360)
Chapter 23 – Berthing & unberthing (pg 361)
Chapter 25 – Ropework (pg 386)

Australian Boating Manual
Capt. Dick Gandy
Chapter 8 – Berthing (or mooring) lines (pg 170)
Chapter 4 – Size of mooring ropes (pg 78)



Online Resources
Mooring - https://en.wikipedia.org/wiki/Mooring

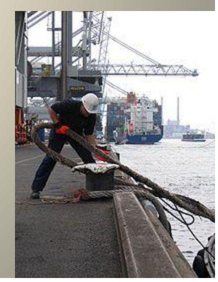
https://mfame.guru/fatal-injury-crew-member-due-mooring-equipment-failure/

4

Mooring Skills

Mooring Lines

- Check condition before using.
- Store in a well ventilated, dry place out of sunlight.
- Do not stand near a rope that is under stress.
- Always keep mooring area clear of loose ropes, wires and debris.
- Never stand in the bight of a rope.
- Beware of safe working loads (S.W.L)



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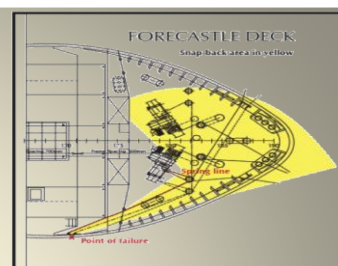
Mooring Skills



Mooring Lines

- Consider large tidal ranges when mooring for long periods.
- Do not lead over sharp corners, especially if under strain.
- Use only three turns around a warping head.
- Always use correct knots.
- Never place hands or fingers between lines and bollards or cleats.
- Ensure mooring area is kept free of loose ropes, wires and debris.
- Retrieve mooring lines that drop into the water as soon as possible to avoid the line fouling the propeller
- Be aware of rope “snap back” zones and always stay clear of that area

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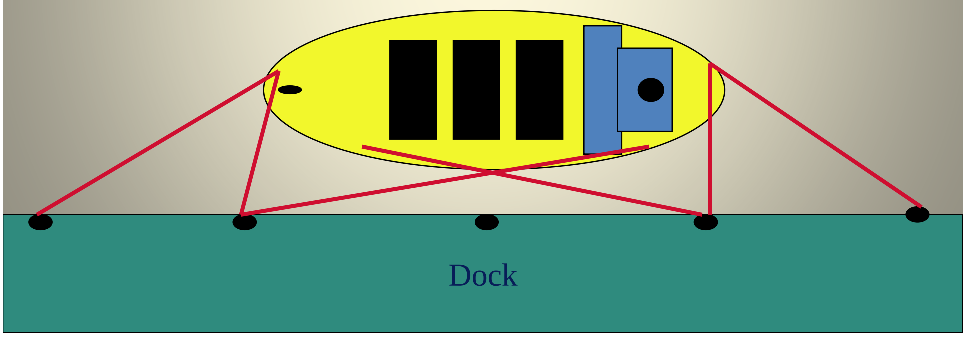
Mooring Lines

Head Line
Forward Spring Line
Aft Spring Line
Stern Line
Forward Breast Line
Aft Breast Line



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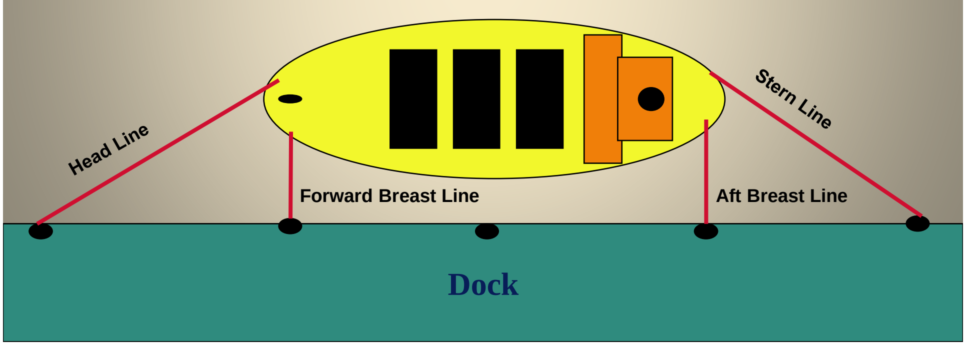
Mooring Lines

Vessel moves up and down with tidal range

Static Dock (not floating)

Note angle and scope of head line



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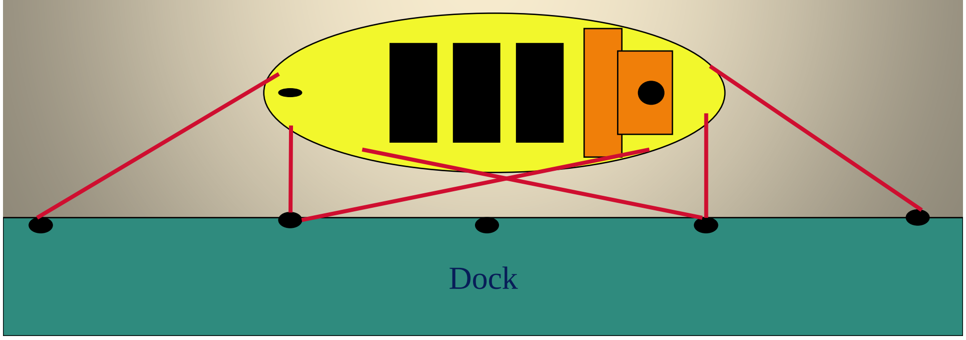
Mooring Lines

Lets take a look at the six most common mooring lines used to secure your vessel to the Dock



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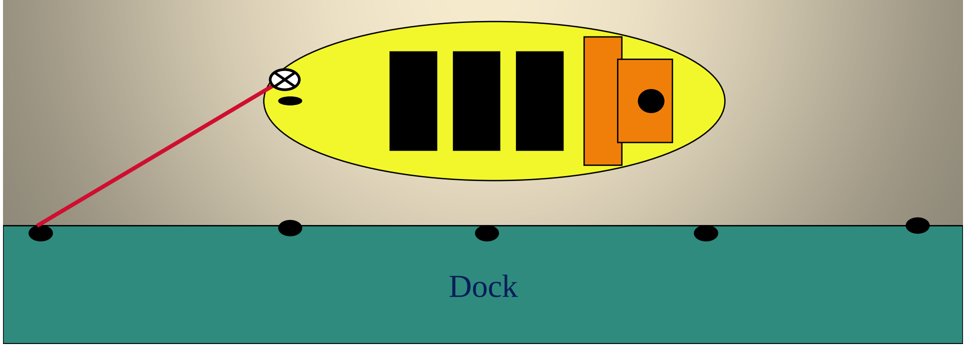
Mooring Lines

Head Line

- Used to keep the bow (or head) of the vessel against the dock
  (Usually attached to the outer quarter of the vessel)



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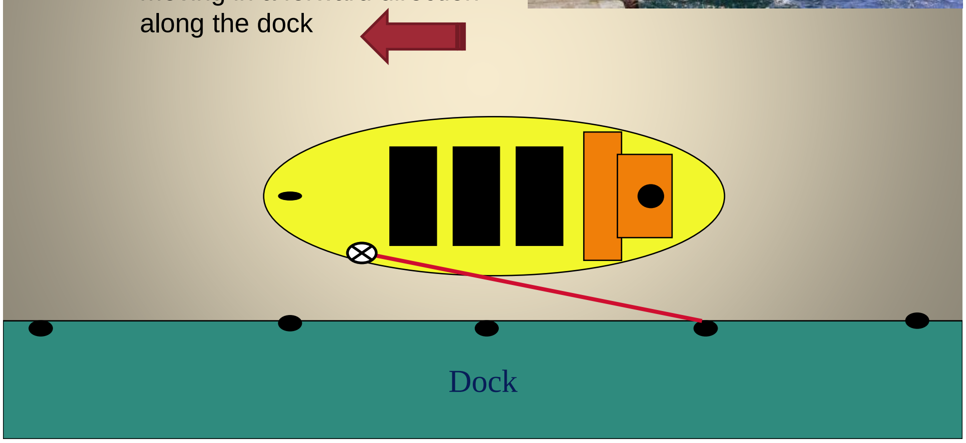
Mooring Lines

Forward Spring Line

- Used to prevent the vessel moving in a forward direction along the dock



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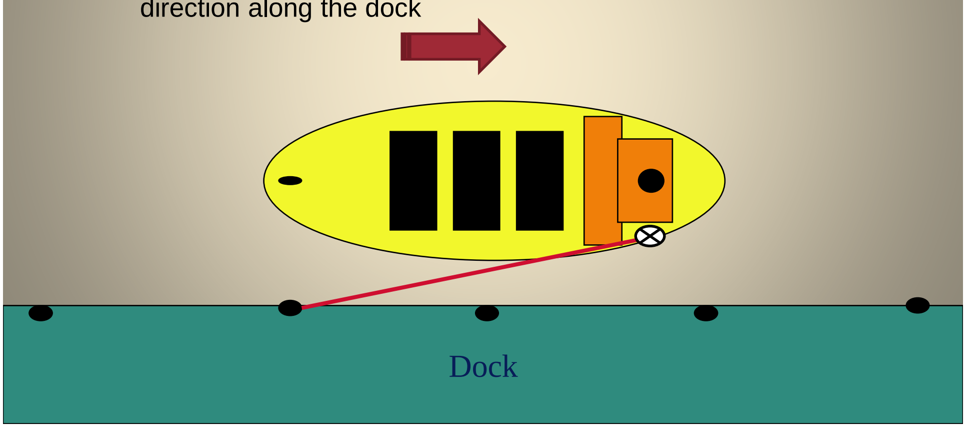
Mooring Lines

Aft Spring Line

- Used to prevent the vessel moving in a backward (or aft) direction along the dock



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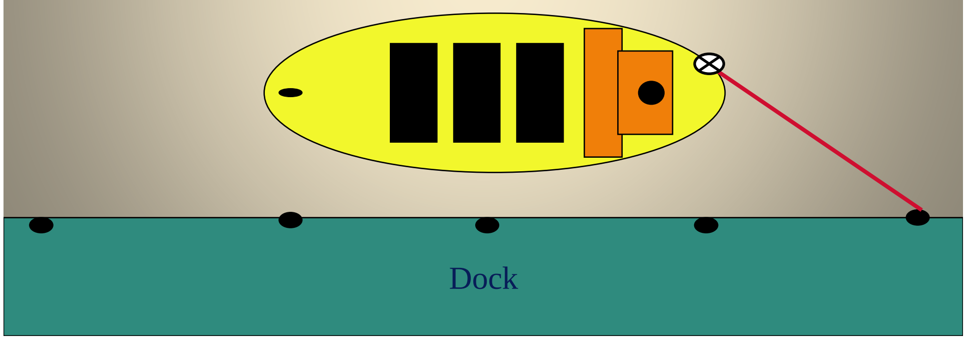
Mooring Lines

Stern Line

- Used to keep the stern of the vessel against the dock
  (Usually attached to the outer quarter of the vessel)



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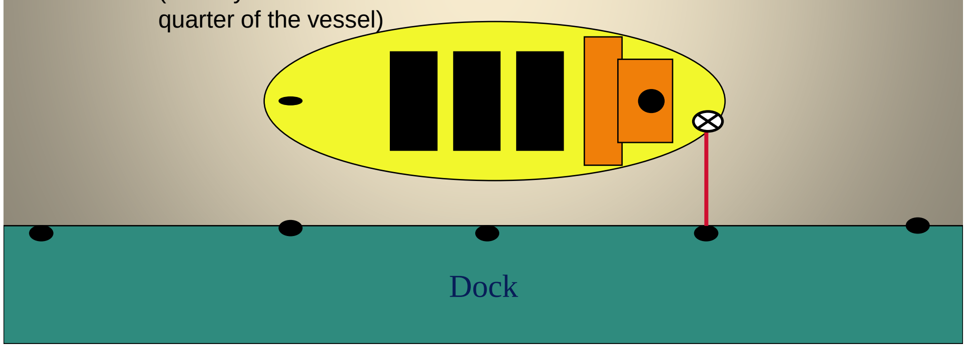
Mooring Lines

Aft Breast Line

- Used to keep the stern of the vessel "up tight" against the dock on arrival and when embarking / disembarking passengers or loading / unloading cargo
  (Usually attached to the inner quarter of the vessel)



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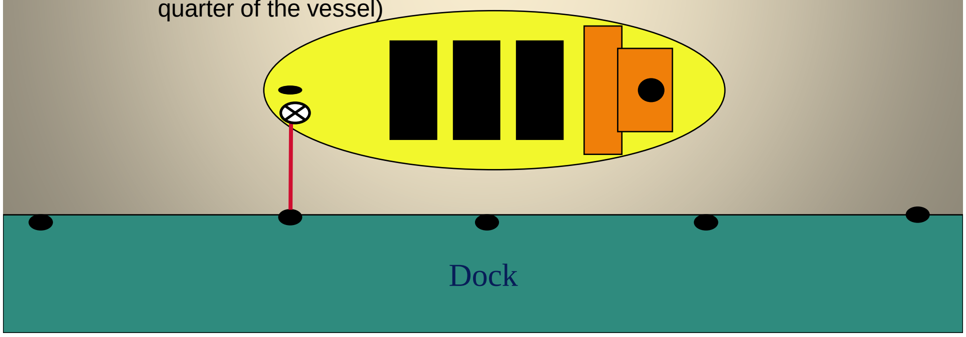
Mooring Lines

Forward Breast Line

- Used to keep the Bow of the vessel "up tight" against the dock on arrival and when embarking / disembarking passengers or loading / unloading cargo
  (Usually attached to the inner quarter of the vessel)



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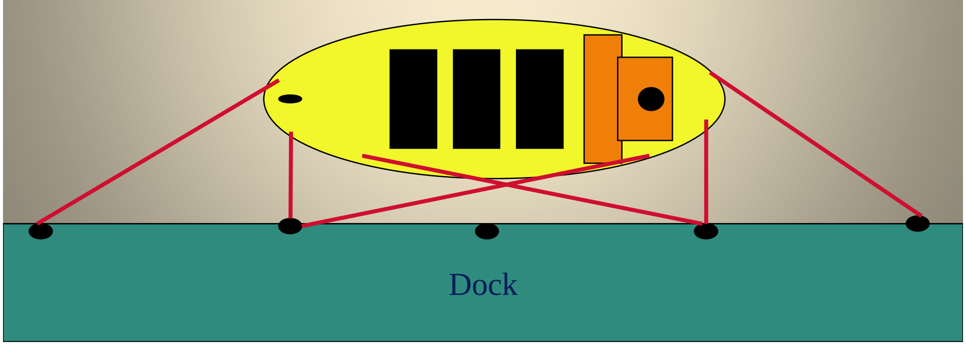
Mooring Lines

Now lets look at the order in which these lines are typically secured when arriving to berth



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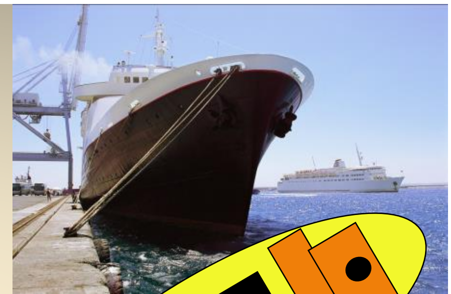
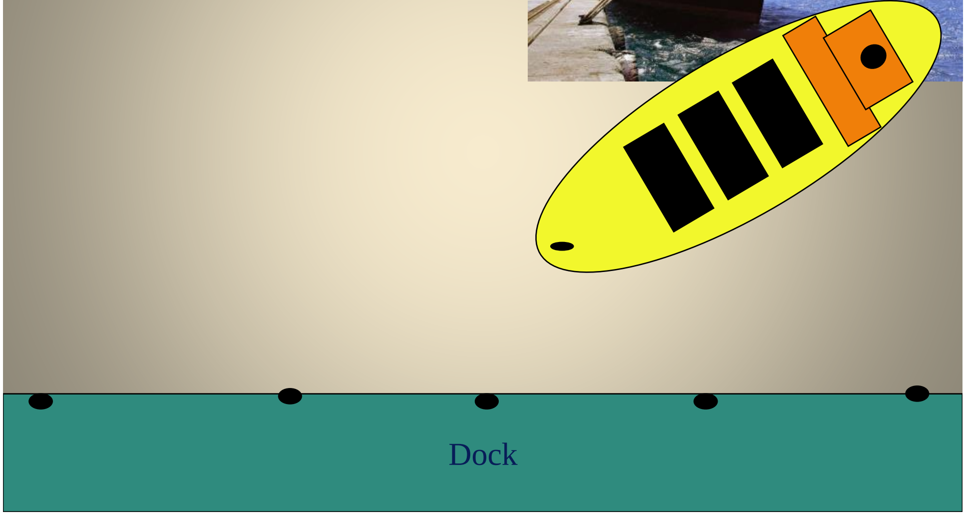
Mooring Lines

The vessel approaches the dock with the view to berth Port Side too





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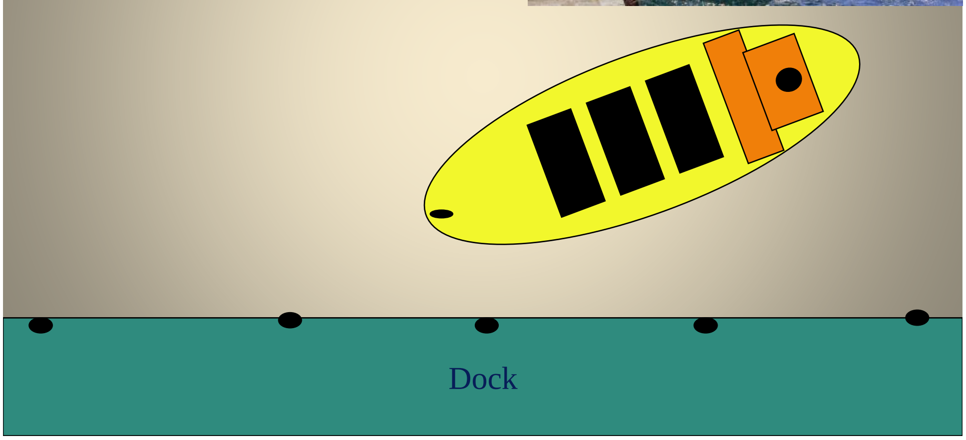
Mooring Lines

The vessel slows as it approaches the dock and keeps “bow in / stern out” presenting on an angle to the dock



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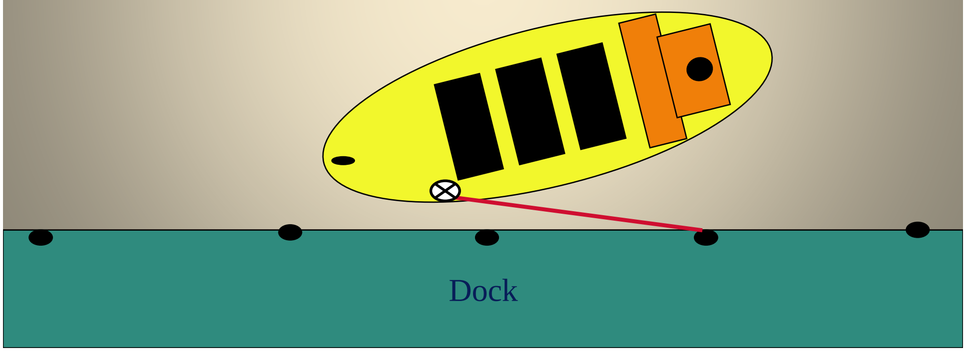
Mooring Lines

As the vessel nears the dock, the first line attached is the forward spring



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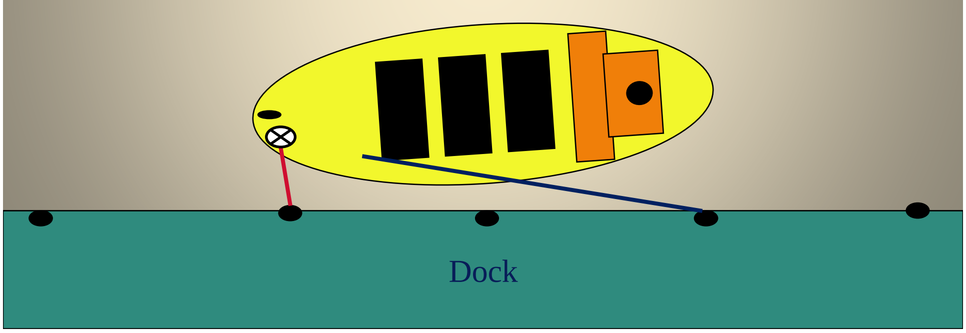
Mooring Lines

As the vessel “pulls up” on the forward spring, the next line attached is the forward breast line. With the vessel still moving forward slowly, the effect is to start bringing the stern towards the dock



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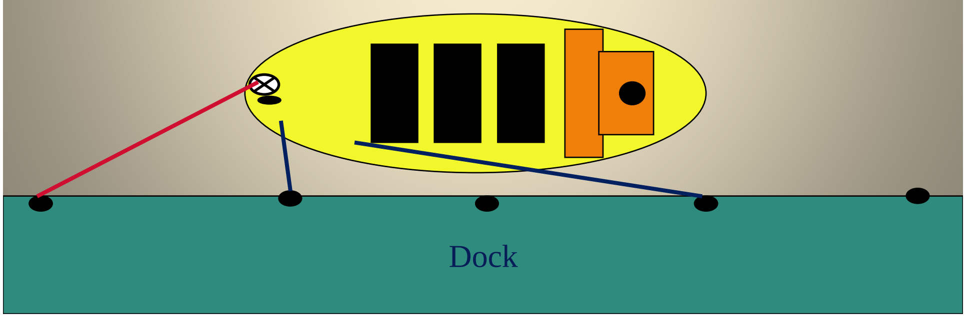
Mooring Lines

While the vessel is in this position, the head line is secured



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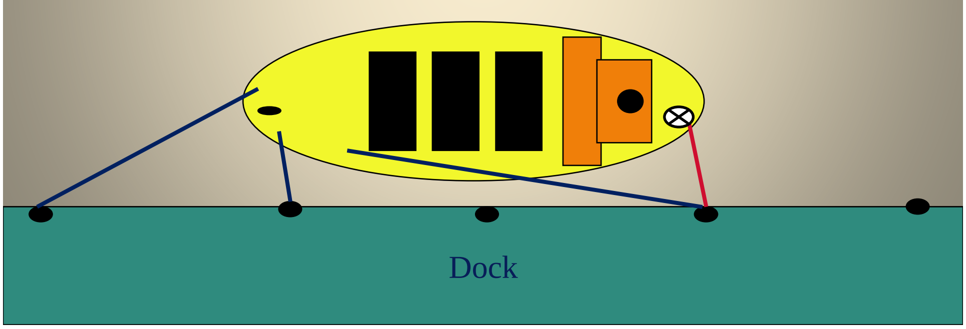
Mooring Lines

With the vessel “pushing up’ against the forward lines (either by momentum or under power) the stern is brought in and the aft breast line is secured



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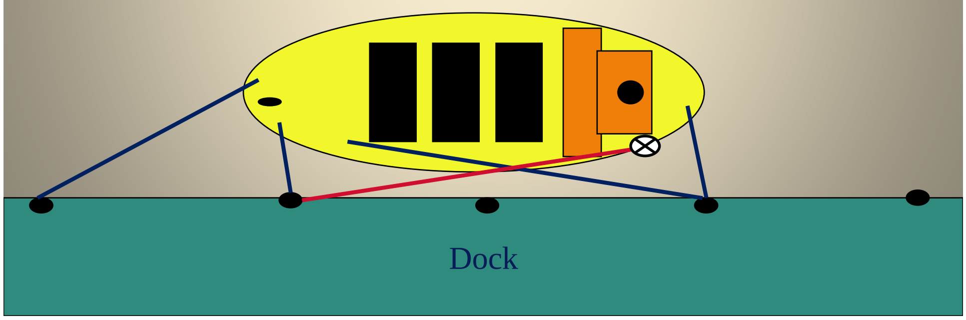
Mooring Lines

With the vessel still pushing up on the forward lines, the aft spring line is attached “tight up” thus preventing movement fore and aft (due to both spring lines now being under tension)



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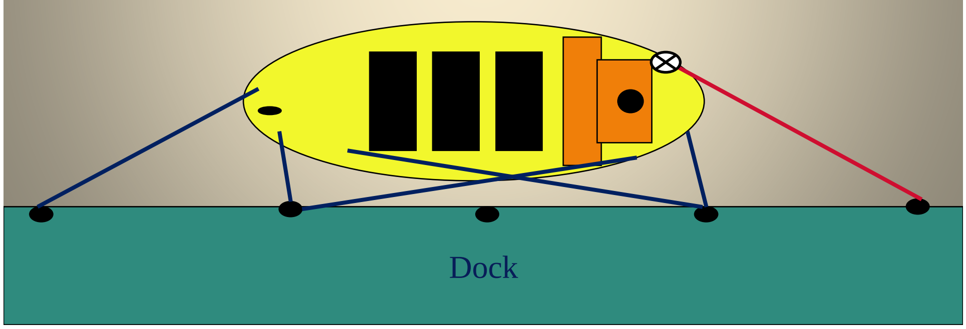
Mooring Lines

Finally, the stern line is secured to the vessel



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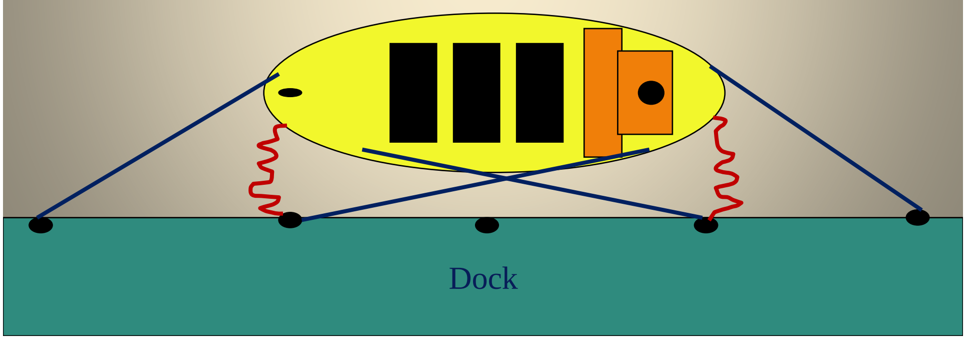
Mooring Lines

If the vessel is to remain on the dock throughout tidal ranges, let off the aft and forward breast lines and give plenty of scope, this allows the vessel to 'ride" the tidal differences



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Dipping The Eye

Line from your vessel

Line from another vessel

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Dipping The Eye



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Power Leads and other Umbilical's

Once the vessel is secured to the wharf or dock, it is very common practice to connect shore based leads or other umbilicals to provide services to the vessel. These can include:

- Shore power leads
- Water hoses
- Data cabling
- Fuel hoses
- Sullage pump out hoses

With any connection between shore and vessel, it is essential that there is sufficient scope on leads etc to allow for vessel and tidal movement. Tension on shore power leads and other umbilicals should be monitored.

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Power Leads and other Umbilical's

Generally speaking, shore-power leads tend to be left connected and the vessel often unattended, introducing many inherent dangers. Good practice includes;

- Inspect shore-power leads for general condition.
- Lead should be tested and tagged.
- Check that the shore power board is protected by an RCD.
- Make sure there is sufficient scope on the lead so it can move up and down with tidal range.
- Leads are positioned to avoid the risk of mechanical damage from dock operations and vessel movement.
- Ensure the lead isn't a trip hazard or in a traffic area.
- Electrical loads onboard are minimised
- Check polarity

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Study Note

- You should be able to explain the what the following terms are;
  - Snap back zone
  - Bight of a rope
- What dangers are associated with these areas? What could occur if something went wrong?

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Thankyou

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ROPES, KNOTS AND SPLICES

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Ropes, Knots and Splices

On completing this session

You will

- ✓ Understand basic rope construction
- ✓ Be able to identify different types of rope
- ✓ Describe simple rope terminology
- ✓ Be able to determine safe working loads of ropes and chains
- ✓ Explain how to determine breaking strains of ropes and chains
- ✓ Identify various rope knots and how to tie these knots
- ✓ Explain common uses and applications of various knots
- ✓ Be able to demonstrate how to splice common rope splices

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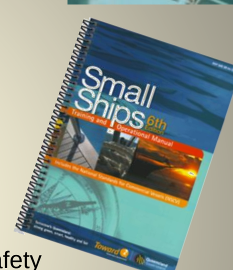
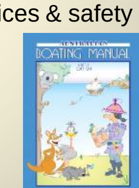
Ropes, Knots and Splices

Recommended Study Reference



Small Ships Training and Operational Manual – Edition 6
Maritime Safety Queensland
Chapter 25 – Ropework (pg 386)

Australian Boating Manual
Capt. Dick Gandy
Chapter 4 – Ropes, knots, splices & safety



Online Resources
Ropes - https://en.wikipedia.org/wiki/Rope

Wire Ropes - https://www.steelwirerope.com/WireRopes

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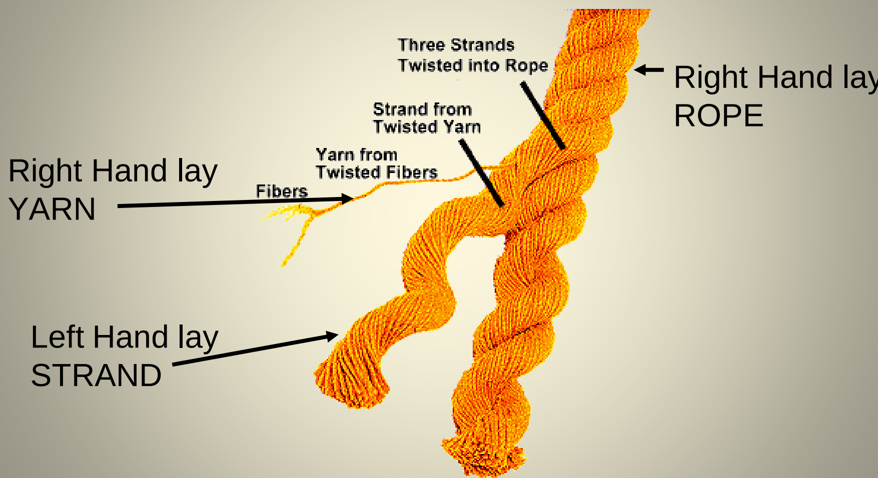
Rope Construction



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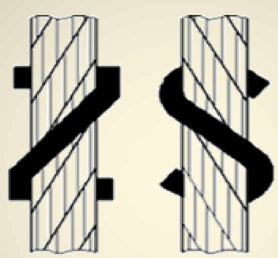
Rope Construction

How to distinguish the difference between Right-Hand & Left Hand Laid Ropes



Right–Hand Laid Rope
("Z") Twist

Left–Hand Laid Rope
("S") Twist

In a Right-Hand lay, the direction of the twist of the strands is clock-wise or Z shaped.

In a Left-Hand lay, the direction of the twist of the strands is anti-clock-wise or S shaped.

- Note that it does not alter if you were to turn the illustration around.

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Rope Construction

Differently Constructed Ropes

- Hawser Laid Ropes (also called three strand rope)
  - These are by far the most common type of rope. Easy to work with and to splice. These ropes are *right-hand laid* with three strands, and are manufactured in three levels of stiffness;
    - Soft Lay – very soft, has a silky feel but kinks easily
    - Medium Lay – most suitable for boats
    - Hard Lay – difficult to work with on a boat
- Square Ropes
  - Plaiting four left-hand strands into four right-hand strands make a square rope. This rope is tough, kink resistant and flexible and is commonly used for towing and berthing lines.
- Cable Laid Ropes
  - Cable laid ropes are made by twisting three Hawser laid ropes into one, and offers good elasticity for towing lines.

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Rope Construction

Differently Constructed Ropes

- Braided Ropes
  - Consist of the following general types;
    - Single (or solid) braided ropes, usually in 12 or 18 strand
    - Plaited braided ropes, commonly used for flag halyards
    - Double plaited braided ropes, they have a braided core inside a braided jacket, very common on boats.
- Jacketed Parallel-Core Ropes
  - Consists of a number of ropes running parallel to each other inside a thin jacket. A set of seven ropes inside a jacket is common.
- Shroud Laid (four strand) Ropes
  - Is made of 4 strands laid around a fibre core strand. It is around 11% weaker than three strand rope and is not often seen these days.

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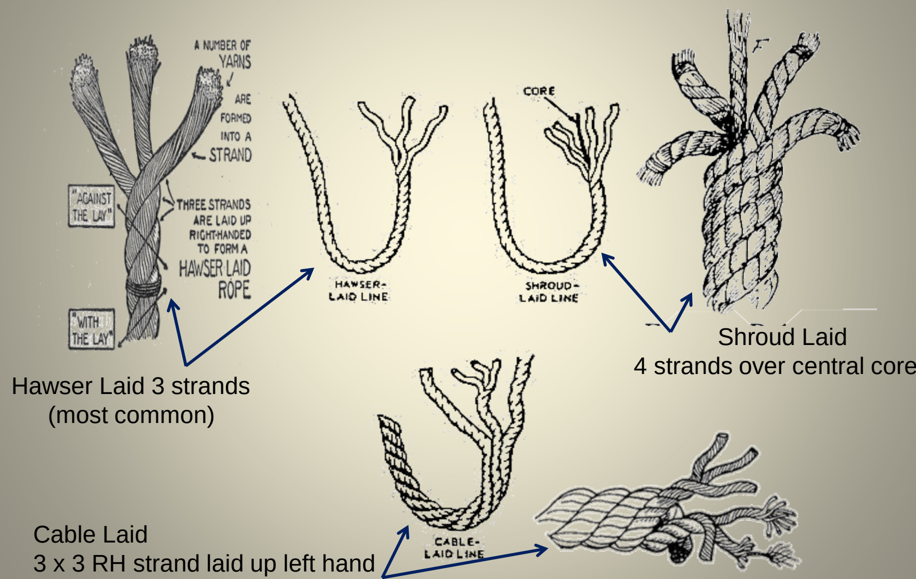
Rope Construction



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Types Of Ropes

When selecting a rope, consider the fibre and construction of a rope to determine if it is appropriate to the environment in which it will be used. Also consider all the possible sources of degradation during use.

Essentially, there are three types of fibre ropes:

1) Natural Fibres

Natural fibres produce a hard wearing, low stretch and general purpose rope. They are made from vegetable fibres such as manila and sisal in short staples.

- Manila rope
- Sisal rope
- Hemp rope

Manila rope

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Types Of Ropes

2) Synthetic Fibres

There is a range of synthetic fibre ropes and each has particular characteristic's suited to specific purposes. We will look at each in greater detail, rope types include;

- Nylon
- Polypropylene
- Polyethylene
- Polyester

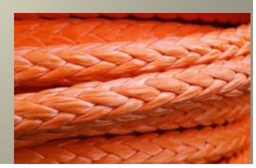
Nylon Rope

3) Exotic Fibres

A small group of synthetic manufactured ropes (the HMPE and aramids) that have extremely high strength, similar to steel wire. The most common are;

- Kevlar (aramid)
- Twaron (aramid)
- Spectra (HMPE)
- Dyneema (HMPE)

Dyneema



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Types Of Ropes (Natural Fibre)

Manila

- Manila is made from natural fibers.
- At one time, it was the best rope fibre available.
- Manila must be handled and stored with care as dampness will cause it to rot.

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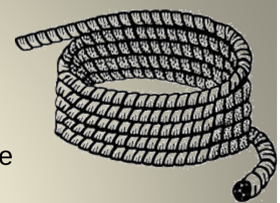
Types Of Ropes (Natural Fibre)

Manila



Specifically, Manila rope is

- Durable, flexible, and resistant to salt water damage
- Shrinks when it becomes wet
- Knots become difficult to untie if the rope and knot gets wet
- Rope will rot after a period of time when exposed to saltwater
- Used for hawsers, ships lines, fishing nets

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Types Of Ropes (Synthetic)

Nylon

- Nylon is a high strength rope
- Breaking stress = 2.25 that of natural fibre rope
- Shrinks when wet
- May lose up to 15% strength when wet
- It has very good resistance to abrasion and will last four to five times longer than natural fibre ropes.

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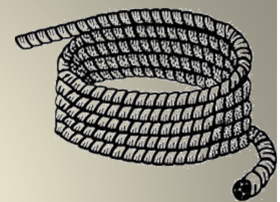
Types Of Ropes (Synthetic)

Nylon



Specifically, Nylon rope is

- Constructed using continuous polyamide fibres
- Very strong
- High stretch
- Good energy absorption from shock loads
- Does not burn but may melt
- Sensitive to acids and prolonged sunlight
- Resists solvents and salts
- Does not float
- Used for slings, safety lines, tow ropes, anchor ropes and mooring lines
- Most dangerous synthetic rope and can break without warning

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Types Of Ropes (Synthetic)

Polypropylene

- Lightweight and strong.
- Breaking stress = 1.6 times that of natural fibre.
- Has about 60% of the strength of nylon and polyester rope.
- Polypropylene rope is available in monofilament fiber, which is smooth surfaced, or multifilament fibre, which has a somewhat velvety appearance and feel.

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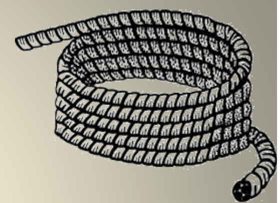
Types Of Ropes (Synthetic)

Polypropylene



Specifically, Polypropylene rope is

- Not as strong as Polyester
- Melts readily and may burn
- Sensitive to solvents and sunlight
- Floats
- Used for slings, nets, tarpaulin ties and control ropes

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Types Of Ropes (Synthetic)

Polyethylene
(Also known as Silver Rope)

- Breaking stress = 1.16 times that of natural fibre rope
- A floating rope somewhat like polypropylene but slightly heavier.
- Polyethylene's handling characteristics are a little different than polypropylene.

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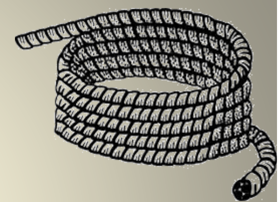
Types Of Ropes (Synthetic)

Polyethylene



Specifically, Polyethylene rope is

- Good stretch and energy absorption
- Good abrasion resistance
- Melts readily and may burn rapidly
- Resistant to most chemicals (not strong acids)
- Sensitive to prolonged sunlight and heat
- Floats
- Used for slings, nets, tarpaulin ties and control ropes

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Types Of Ropes (Synthetic)

Polyester

- A very strong synthetic rope with excellent abrasion resistance.
- Breaking stress = 2.00 times that of natural fibre rope
- Polyester does not have the stretch and elasticity of nylon.
- Polyester is superior to nylon with respect to cycle loading and abrasion.

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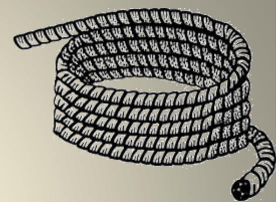
Types Of Ropes (Synthetic)

Polyester



Specifically, Polyester rope is

- Strong
- Good stretch and shock resistance
- Melts
- Sensitive to concentrated acids and alkalis
- Sensitive to prolonged sunlight
- Sinks
- Used for halyards, safety lines, slings and hoist ropes

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Types Of Ropes (Synthetic)

Square Rope

4 Left Hand & 4 Right Hand strands result in a tough, kink resistant rope (towing and mooring lines on larger vessels)

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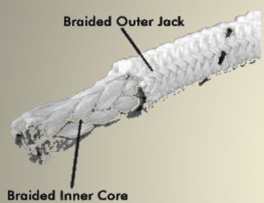
Types Of Ropes (Synthetic)

Braided Cords



Available in several configurations Solid, Hollow, Double Braid

Single Braid

Double Braid

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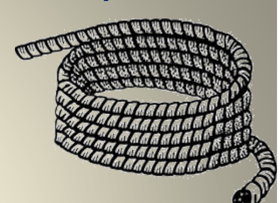
Types Of Ropes (Synthetic)

Braided Cords



Specifically, Braided Cord rope is

- Flexible
- Resistant to abrasions (wear is distributed over many strands)
- Coils easily
- Kink-free
- Generally more difficult to splice
- Nylon jacketed type braid is commonly used for berthing lines
- Polyester jacketed type braid is common for sheets and halyards on sailing vessels

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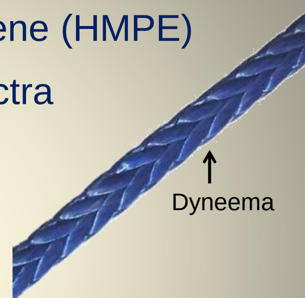
Types Of Ropes (Exotic)

High-Modulus Polyethylene (HMPE)

Dyneema and Spectra

- Very high strength
- Breaking stress = 6 times that of natural fibre
- Very low stretch
- Light weight



Dyneema

Spectra

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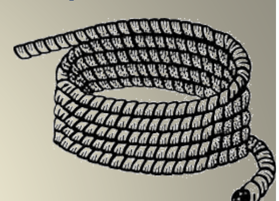
Types Of Ropes (Exotic)

High-Modulus Polyethylene (HMPE)

Dyneema and Spectra



Specifically, these ropes

- Excellent abrasion resistance
- Excellent weather resistance
- Melts (low resistance to heat) melting point 165°C
- Decompose at very high temperatures
- Does not shrink when wet
- Absorbs very little water when wet, so remains lightweight when wet
- Floats

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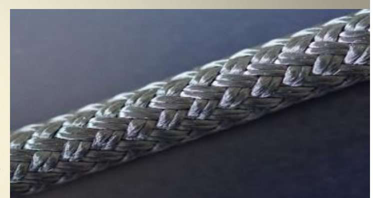
Types Of Ropes (Exotic)

Aramid

Kevlar and Twaron

- Very high strength
- Very stretchy



Twaron

Kevlar

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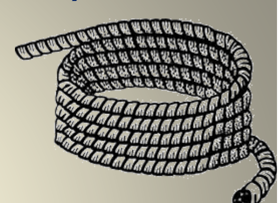
Types Of Ropes (Exotic)

Aramid

Kevlar and Twaron



Specifically, these ropes

- Very high strength
- Poor UV resistance (sensitive to sunlight)
- Poor abrasion resistance
- Melts (medium resistance to heat) melting point 500°C
- Poor knot strength
- Does not float

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Care and Storage of Rope

What Damages Fibre Ropes?

Various factors and situations can cause damage to ropes, the following are among the more common;

- Abrasion or cutting on sharp objects
- Excessive stress
- Sudden shock loads
- Overloading
- Heat
- Chemicals
- Moisture
- Salt deposits
- Poor stowage
- Unnecessary or prolonged exposure to sunlight

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Care and Storage of Rope

Care of Fibre Ropes

The following practices will help prolong the strength and life of a fibre rope;

- Keep ropes clean (hose down and dry)
- Keep ropes clear of chemicals and oils
- Avoid excessive heat (including from friction and drums)
- Stow in a dry, well ventilated position (avoid risk of mildew)
- Stow out of weather and sunlight
- Avoid overloading and shock loads
- Avoid abrasion and running lines over sharp edges
- Avoid kinks and remove knots
- Avoid mismatched running gear
- Don’t drag ropes over rough ground

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Care and Storage of Rope

Inspecting Fibre Ropes

Inspect ropes regularly for abrasion, cuts, discolouration, distortion, burns, rot, mildew, broken fibres and powdery fibres. Any of these conditions signify a loss of strength.

- If the rope is suspect in one spot, the damaged section should be cut out and the ends joined by splicing. Always include one metre either side from the damaged section.
- Damaged rope intended for use in life rescue or other critical operations must be condemned if there is any sign of damage.
- If there is any doubt whether a rope has been damaged, it should be condemned

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Fibre Rope Load Forces

Load Terminology

- Strength of fibre ropes essentially depend on;
  - The material from which it is constructed
  - Its size (diameter in mm)
  - Its condition
- Minimum Breaking Force (MBF)
  Is the minimum breaking strength of a rope as supplied by the supplier and is usually the optimum strength achieved under laboratory conditions. In real applications involving various forces and factors the rope will likely fail at a much reduced load. Therefore, the safe working load of any rope is much lower than its nominal strength.
- Working Load Limit (WLL)
  Is the maximum load that should ever be applied to the rope under any condition. The WLL is based on a load being uniformly applied in a straight line pull, thus how the load is slung will affect the WLL.

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Fibre Rope Load Forces

Load Terminology

- Safety Factor (SF)
  It is irresponsible and extremely dangerous to load lines anywhere near the breaking strength. Depending upon application, a safety factor is applied to set the limit to which a rope should be loaded. For general applications around vessels, the safety factor is taken as 6:1 (meaning ropes, as a general rule, should only be loaded up to one sixth of their breaking strength)

Essentially, there are two types of safety factors that can apply to ropes and lifting, being;

- Legal safety factors
  Where a safety factor is prescribed by law, that factor should be used in calculating SWL for rope

- Safety factors dependant on conditions of use

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Fibre Rope Load Forces

Load Terminology

- Safety Factor (SF)

  - Safety factors dependant on conditions of use

Where no safety factor is prescribed by law, safety factors no lower than those shown below should be used. Higher safety factors can be used.

Safety Factors Conditions under which rope is to be used	SF
Ropes not subject to flexing or twisting, for example standing rigging, ropes secured at both ends to non-rotating mounts	5
Ropes subject to occasional flexing or twisting, for example ropes in mad up articles such as slings, tow ropes	6
Ropes used to support persons either directly or indirectly, foe example gantlines securing bosun's chairs or stages, lizards, life rescue ropes	8
Ropes in arduous or continuous use, where the load frequently closely approaches the SWL, or where the rope is continuously exposed to flexing or twisting, for example ropes used to move railway trucks by heaving on a capstan, ropes used in endless belts to drive machinery	9

From AS4142.1.1993

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Fibre Rope Load Forces

Load Terminology

- Safe Working Load

By Definition, Safe Working Load (SWL) *sometimes stated as Normal Working Load (NWL)*

Is the maximum safe force that a piece of lifting equipment, lifting device or accessory can exert to lift, suspend, or lower, a given mass without fear of breaking. Usually marked on the equipment by the manufacturer. It is a calculation of the Minimum Breaking Force (MBF) aka Minimum Breaking Load (MBL) divided by a safety factor, usually ranging from 4 to 6 on lifting equipment. The factor can be as high as or 10 to 1, if the equipment poses a risk to a person's life.

A simple definition, and one easy to remember when working with ropes is;
The Safe Working Load of a rope while being used in continuous operation.

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Fibre Rope Load Forces

Minimum breaking force (MBF) requirements for Three-Strand Hawser-Laid Ropes to AS 4142.2

*NOTE - The minimum breaking force (MBF) must in no way be construed as the safe working load of the rope

Rope Types	Manila & Sisal		Polyamide Rope (Nylon) (from filament fibre)		Polyester Rope (filament fibre)		Polypropylene Rope		Polyethylene Rope (staple fibre)		Polyethylene Rope (monofilament fibre)	
	Kilo newton	*Kilo gram*	*Kilo newton*	*Kilo gram*	*Kilo newton*	*Kilo gram*	*Kilo newton*	*Kilo gram*	*Kilo newton*	*Kilo gram*	*Kilo newton*	*Kilo gram*
Rope Dia (mm)	MBF kN	MBF kG	MBF kN	MBF kG	MBF kN	MBF kG	MBF kN	MBF kG	MBF kN	MBF kG	MBF kN	MBF kG
3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.07	109.11	N/A	N/A
4	N/A	N/A	3.15	321.21	2.90	295.71	2.10	214.14	2.04	208.02	1.96	199.86
5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.63	268.18	N/A	N/A
6	2.55	260.02	7.35	749.48	5.54	564.91	4.48	456.83	3.69	376.27	3.92	399.72
7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4.85	494.55	N/A	N/A
8	4.73	482.32	13.20	1,346.00	10.00	1,019.70	10.40	1,060.49	6.10	622.02	6.86	699.51
9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7.57	771.91	N/A	N/A
10	6.22	634.25	20.40	2,080.19	15.60	1,590.73	15.30	1,560.14	9.26	944.24	10.70	1,091.08
12	9.36	954.44	29.40	2,997.92	22.30	2,273.93	21.70	2,212.75	12.40	1,264.43	15.10	1,539.75
14	12.60	1,284.82	40.20	4,099.19	31.20	3,181.46	29.90	3,048.90	14.10	1,437.78	20.50	2,090.39
16	17.70	1,804.87	52.00	5,302.44	39.80	4,058.41	37.00	3,772.89	20.80	2,120.98	27.50	2,804.18
18	21.00	2,141.37	65.70	6,699.43	49.80	5,078.11	47.20	4,812.98	25.40	2,590.04	34.00	3,466.98
20	27.90	2,844.96	81.40	8,300.36	62.30	6,352.73	56.90	5,802.09	31.00	3,161.07	41.90	4,272.54
22	33.40	3,405.80	98.00	9,993.06	74.70	7,617.16	68.20	6,954.35	36.80	3,752.50	49.80	5,078.11
24	39.90	4,068.60	118.00	12,032.46	89.60	9,136.51	79.70	8,127.01	43.10	4,394.91	59.80	6,097.81
28	52.20	5,322.83	155.00	15,805.35	120.00	12,236.40	105.00	10,706.85	58.30	5,944.85	80.50	8,208.59
32	67.30	6,862.58	196.00	19,986.12	154.00	15,703.38	132.00	13,460.04	76.20	7,770.11	105.00	10,706.85
36	85.30	8,698.04	244.00	24,880.68	190.00	19,374.30	166.00	16,927.02	96.30	9,819.71	132.00	13,460.04
40	103.00	10,502.91	294.00	29,979.18	235.00	23,962.95	201.00	20,495.97	119.00	12,134.43	160.00	16,315.20
48	145.00	14,785.65	412.00	42,011.64	329.00	33,548.13	280.00	28,551.60	168.00	17,130.96	224.00	22,841.28
56	195.00	19,884.15	549.00	55,981.53	439.00	44,764.83	371.00	37,830.87	229.00	23,351.13	298.00	30,387.06
64	252.00	25,696.44	706.00	71,990.82	568.00	57,918.96	480.00	48,945.60	299.00	30,489.03	383.00	39,054.51
72	321.00	32,732.37	882.00	89,937.54	707.00	72,092.79	603.00	61,487.91	379.00	38,646.63	481.00	49,047.57
80	380.00	38,748.60	1,078.00	109,923.66	867.00	88,407.99	741.00	75,559.77	468.00	47,721.96	592.00	60,366.24

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Fibre Rope Load Forces

Calculating Safe Working Load

- The relationship between Safe Working Load and Minimum Breaking Force *(often referred to as the "rule of thumb" relationship)*

The relationship between Safe Working Load (SWL), Minimum Breaking Force (MBF) and Safety Factor (SF) can be defined as follows;

A ropes safe working load is equal to its minimum breaking force divided by a safety factor

$$\textbf{SWL} = \frac{\textbf{BF}}{\textbf{SF}}$$

BF = the Breaking Force (minimum breaking force)
SF = a Safety Factor

Same thing, put another way is
SWL = BF ÷ SF

Put simply, to calculate Safe Working Load (SWL) we must first establish the Minimum Breaking Force (MBF) of the rope to be used, then apply a Safety Factor (SF) which is divided from the Breaking Force.

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Fibre Rope Load Forces

$$\textbf{SWL} = \frac{\textbf{BF}}{\textbf{SF}}$$

Calculating Safe Working Load

To calculate Safe Working Load (SWL) we must first establish the Minimum Breaking Force (MBF) of the rope to be used, then apply a Safety Factor (SF) which is divided from the Breaking Force.

Now lets take a look at this in practice

We will use the following as examples;

- We want to calculate the safe working load of a rope we have on our vessel. We know it is a Polypropylene rope with a diameter of 14mm, and we have access to our MBF chart.
  We plan to use it as a sling. What is the SWL?

First, go to our MBF chart and look down in the Polypropylene column and across from our 14mm rope dia. We can see that the MBF for this rope is 3,048.90 Kg (call it 3,048) {always round down} Then apply our formula:

$$\textbf{SWL} = \frac{\textbf{3048}}{\textbf{6}}$$

(3048 BF taken from MBF chart)
(6 SF taken from SF chart)

SWL for this rope in this application
SWL = 508 Kg

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Fibre Rope Load Forces

SWL = $\frac{\textbf{BF}}{\textbf{SF}}$

Calculating Safe Working Load

To calculate Safe Working Load (SWL) we must first establish the Minimum Breaking Force (MBF) of the rope to be used, then apply a Safety Factor (SF) which is divided from the Breaking Force.

Now lets take a look at this in practice

We will use the following as examples;

- We plan to hoist a crew member up a mast in a bosun's chair and we only have an 8mm Manila rope. The crew member, including equipment weighs 140 Kg. We have access to our MBF chart.
  Can we use this rope? What is the SWL?

First, go to our MBF chart and look down in the Manila column and across from our 8mm rope dia. We can see that the MBF for this rope is 482.32 Kg (call it 482) {always round down} Then apply our formula:

SWL = $\frac{\textbf{482}}{\textbf{8}}$ *(482 BF taken from MBF chart)*
(8 SF taken from SF chart)

SWL for this rope in this application
SWL = 60.25 Kg (cannot use this rope)

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Fibre Rope Load Forces

SWL = $\frac{\textbf{BF}}{\textbf{SF}}$

Calculating Safe Working Load

To calculate Safe Working Load (SWL) we must first establish the Minimum Breaking Force (MBF) of the rope to be used, then apply a Safety Factor (SF) which is divided from the Breaking Force.

Now lets take a look at this in practice

Using the same example;

- We plan to hoist a crew member up a mast in a bosun's chair and we only have an 8mm Manila rope. The crew member, including equipment weighs 140 Kg. We have access to our MBF chart.
  What rope can we use?

Let's work the other way. We have 140 Kg and in this case a SF of 8
140 x 8 = 1120 Kg
Now using our MBF chart, find suitable ropes with this breaking force.
Manila needs to be 14mm, Nylon could be 8mm, Polyethylene needs to be 12mm

SWL = $\frac{\textbf{1284}}{\textbf{8}}$ *(1284BF taken from MBF chart) {for manila}*
(8 SF taken from SF chart)

SWL for this rope in this application
SWL = 160.5 Kg

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Fibre Rope Load Forces

Calculating Safe Working Load

- How do we calculate SWL if we don't have access to a MBF chart?
  You could be at sea, no MBF chart and you need to select a suitable rope for a task.

Another way to calculate SWL (although not as accurate as using an MBF chart as shown previously) is to multiply the diameter of the rope squared then multiply by a rope type factor. Thus, SWL = D^2 x F

The applicable rope factors are as follows;

- Manila & Sisal and Silver ropes = 1 (applies to all natural fibres)
- Polyamide (Nylon) rope > 50mm = 2.5
- Polyamide (Nylon) rope < 50mm = 3
- Polyester rope = 2
- Polypropylene rope = 1.5
- Polyethylene (staple fibre) rope = 1.2
- Polyethylene (mono fibre) rope = 1.8

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Fibre Rope Load Forces

Calculating Safe Working Load

- How do we calculate SWL if we don't have access to a MBF chart?

Examples

- We have a 12mm manila rope, no MBF information. What is the SWL?
  SWL = D^2 x F
  SWL = 12{dia} x 12{dia} x 1{rope factor}
  SWL = 144 Kg

- We have a 18mm polyester rope, no MBF information. What is the SWL?
  SWL = D^2 x F
  SWL = 18{dia} x 18{dia} x 2{rope factor}
  SWL = 648 Kg

- We have a 22mm nylon rope, no MBF information. What is the SWL?
  SWL = D^2 x F
  SWL = 22{dia} x 22{dia} x 3{rope factor}
  SWL = 1452 Kg

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Fibre Rope Load Forces

Calculating Safe Working Load

- How do we calculate Minimum Breaking Force if we don't have access to a MBF chart? Simply calculate the SWL, then multiply by 6 (SWL x 6)

Using the same examples

- We have a 12mm manila rope, no MBF information. What is the SWL?
  SWL = D2 x F
  SWL = 12{dia} x 12{dia} x 1{rope factor}
  SWL = 144 Kg To calculate MBF (SWL x 6) 144 x 6 = 864Kg

- We have a 18mm polyester rope, no MBF information. What is the SWL?
  SWL = D2 x F
  SWL = 18{dia} x 18{dia} x 2{rope factor}
  SWL = 648 Kg To calculate MBF (SWL x 6) 648 x 6 = 3888Kg

- We have a 22mm nylon rope, no MBF information. What is the SWL?
  SWL = D2 x F
  SWL = 22{dia} x 22{dia} x 3{rope factor}
  SWL = 1452 Kg To calculate MBF (SWL x 6) 1452 x 6 = 8712Kg

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Fibre Rope Load Forces

Calculating Safe Working Load

- As an exercise, we should compare our manually calculated SWL to that of the method using the MBF chart

Using the same examples

- 12mm manila rope

No MBF information SWL = 144 Kg and MBF = 864Kg
Using MBF information SWL = 159 Kg and MBF = 954.44Kg *(SF used was 6)*

- 18mm polyester rope

No MBF information. SWL = 648 Kg and MBF = 3,888Kg
Using MBF information SWL = 846.3 Kg and MBF = 5,078.11Kg *(SF used was 6)*

- 22mm nylon rope

No MBF information SWL = 1452 Kg and MBF = 8,712Kg
Using MBF information SWL = 1,665.5 Kg and MBF = 9,993.06Kg *(SF used was 6)*

As you can see, using the manufactures MBF charts provided for more accurate and increased capacity. This could result in savings and a greater scope of safety. However, using the manual calculation does give a greater safety margin for a given size and type of rope.

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Fibre Rope Load Forces

Knots & Slices lower the MBF and SWL of ropes

- Hard eye splice 10%loss
- Soft eye splice 20%loss
- Bowline, Clove Hitch & Sheet Bend 40%loss
- Fisherman's Bend, Round Turn and Timber Hitch 30 % loss
- Reef Knot 55%




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Types Of Knots



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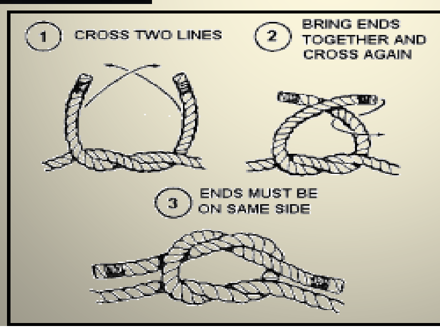
Reef Knot

For joining 2 ropes of EQUAL diameter



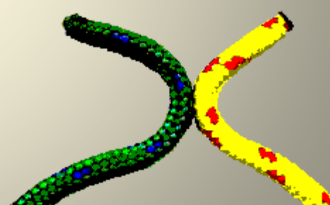


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Figure Of Eight Knot

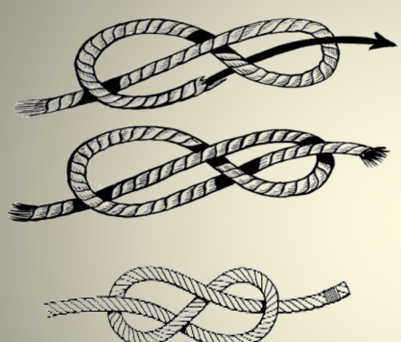
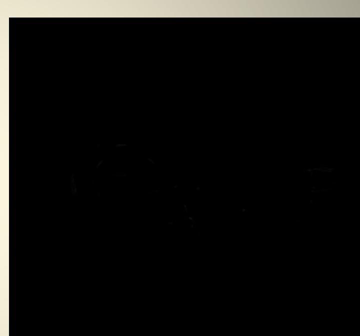


Figure Eight Knot



Used as a stopper to prevent line from running through a block

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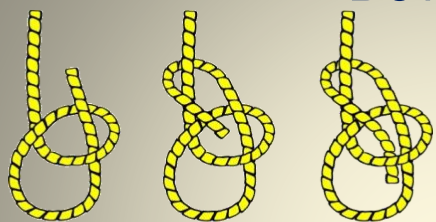
Bowline



- For making a temporary eye
- Easily untied

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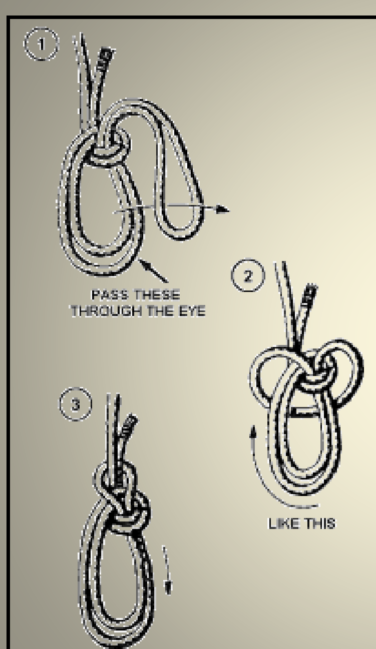

Bowline On The Bight

For making a temporary Bosun’s Chair

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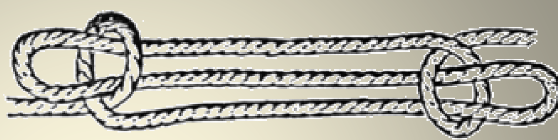
Sheep Shank



For Shortening a Rope

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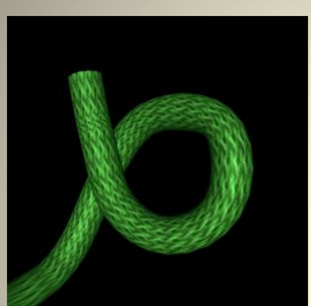
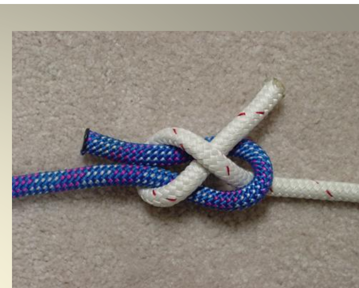
Sheet Bend





Single Sheet Bend

For joining 2 ropes of DIFFERENT diameter

Double Sheet Bend

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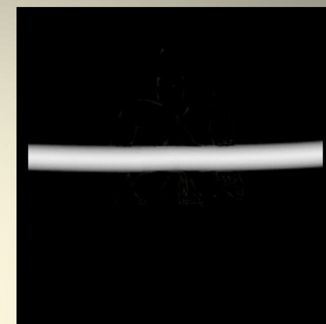
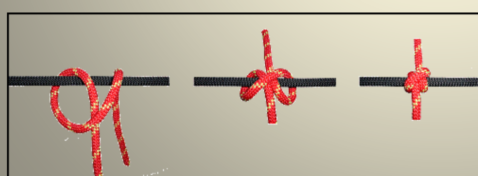
Clove Hitch





- Secures end of line under tension
- Not for high loads - will not come undone

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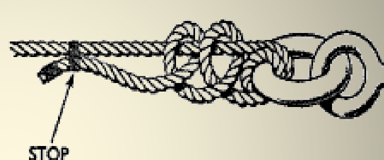
Round Turn And Two Half Hitches



Round Turn and Two Half-Hitches

For securing to a bollard, spar or ring

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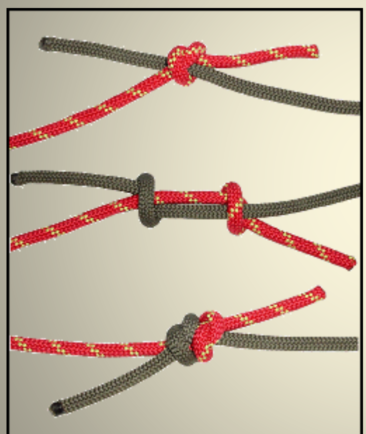
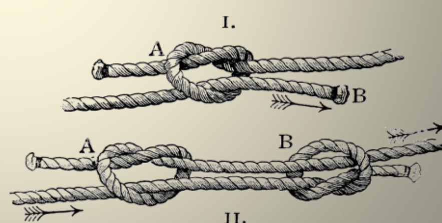
Fisherman’s Bend



Joining 2 lines that must pass through a narrow opening



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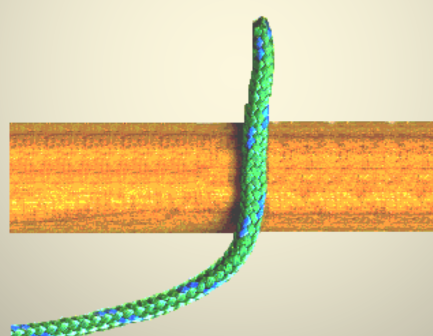
Rolling Hitch



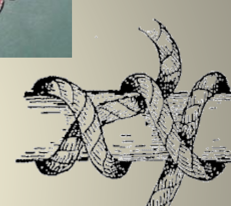


FIG. 48.—Rolling hitch.

Similar to CLOVE hitch – Used to Secure Fenders

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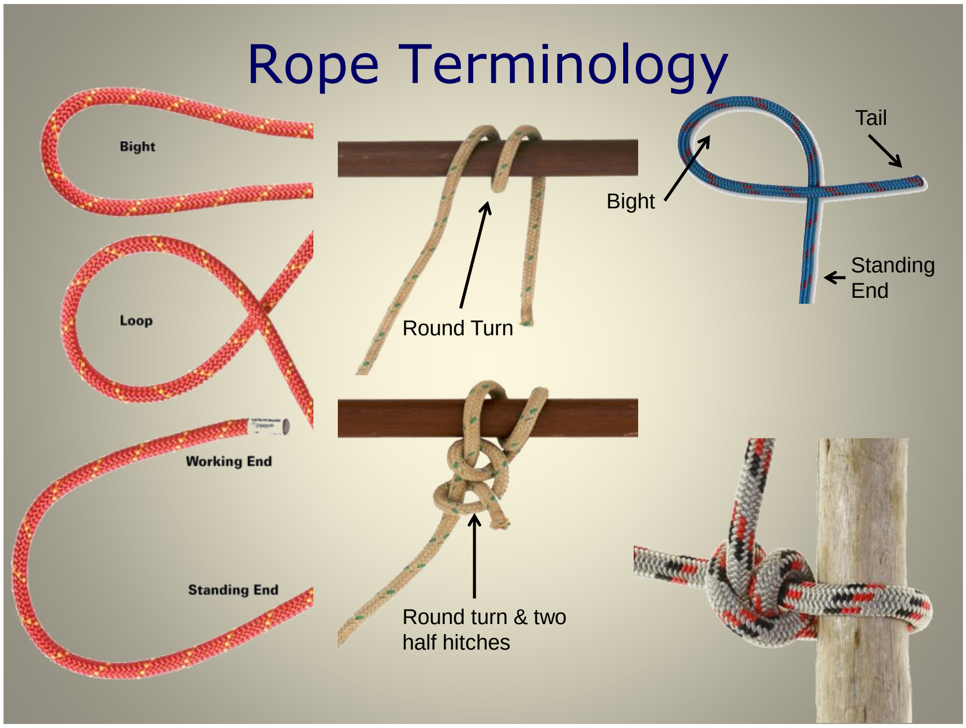
Rope Terminology
Bight
Loop
Working End
Standing End
Round Turn
Round turn & two
half hitches
Bight
Tail
Standing
End

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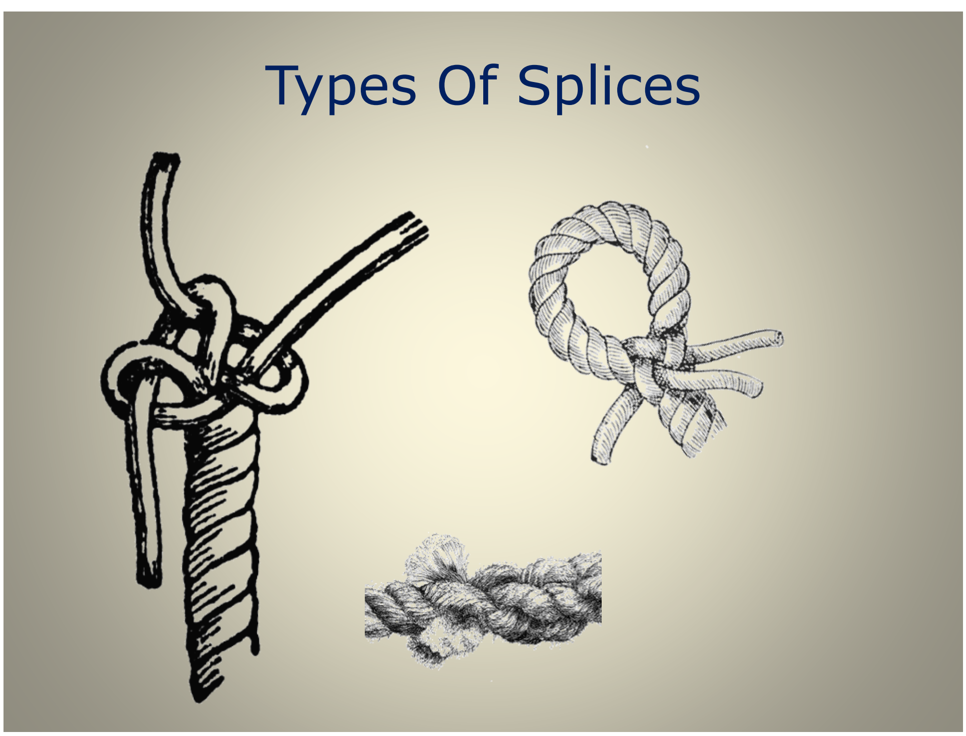
Types Of Splices

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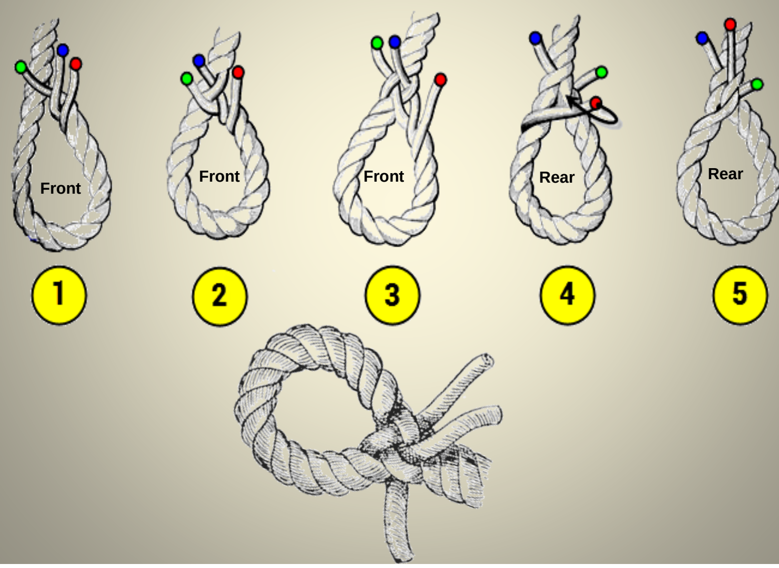
Eye Splice



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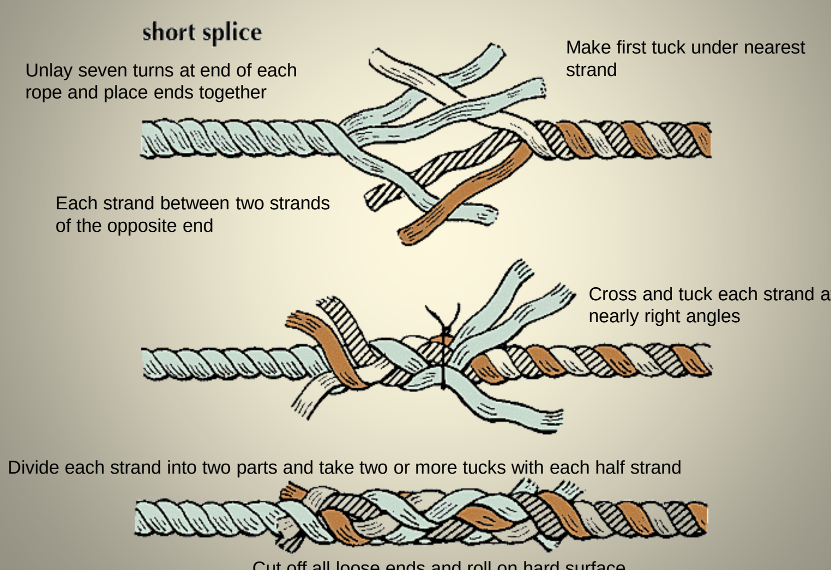
Splice Ends Together



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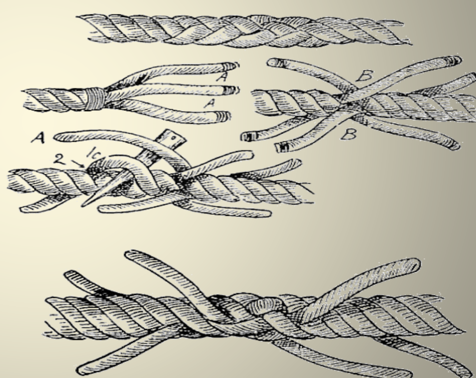
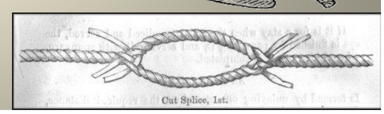
Splice Ends Together

Short Splice

- Used to join two lines together
- Increases the diameter of the line so it isn't suitable for lines that go through blocks
- A long splice should be used when you want to maintain the same diameter (but a long splice doesn't have very much strength)



CUT SPLICE



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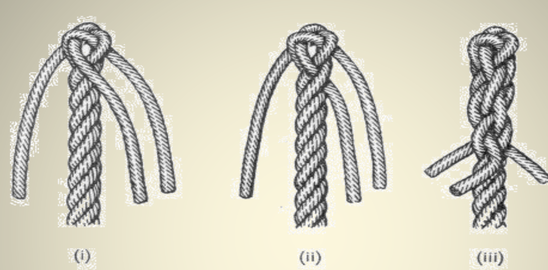
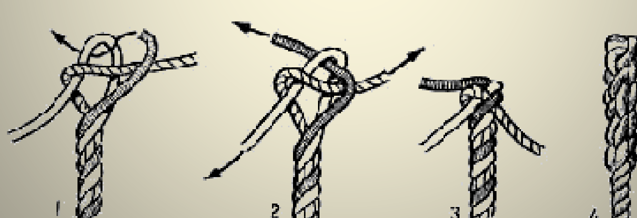
Back Splice





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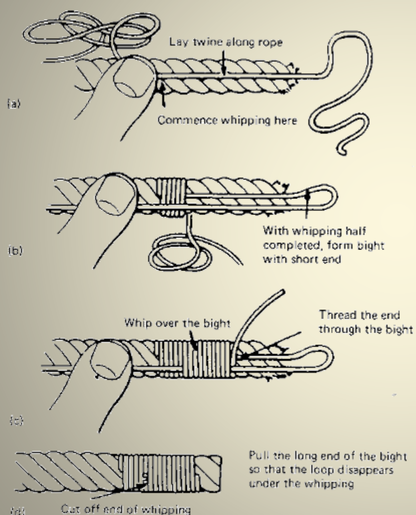
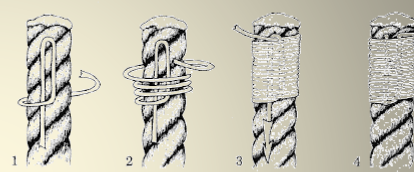
Whipping The End Of A Rope





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Study Note

- Make a list of things that damages rope, and describe how you would store rope.
- Can you describe the different ways to prevent ropes fraying apart at the ends?
- Can you describe what a whipping is? Why do we do this {a number of reasons}

94

Thankyou

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ECA Maritime COLLEGE

LIFTING EQUIPMENT AND HYDRAULICS

96

Lifting Equipment And Hydraulics

On completing this session

You will

- ✓ Understand the use of Purchase and Tackle systems
- ✓ Be able to describe Mechanical Advantage
- ✓ Understand OH&S and Legislation as it applies to lifting equipment
- ✓ Be able to explain how simple hydraulic systems operate
- ✓ Be able to describe hydraulic pumps and switchboard control
- ✓ Have a knowledge of hydraulic hazards
- ✓ Have a stronger understanding of winches, cranes and derricks
- ✓ Describe maintenance requirements of winches and cranes
- ✓ Understand precautions to be taken around deck machinery operations
- ✓ Have knowledge of the survey requirements for lifting equipment

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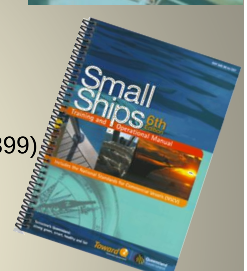
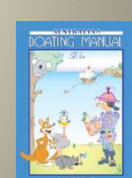
Lifting Equipment And Hydraulics

Recommended Study Reference



Small Ships Training and Operational Manual – Edition 6
Maritime Safety Queensland
Chapter 25 – Purchases and Tackles (pg 399)
Chapter 25 – Cargo Handling (pg 402)
Chapter 18 – Deck Machinery (pg 299)

Australian Boating Manual
Capt. Dick Gandy
Chapter 9 – Lifting Equipment, Winches & Safety
Chapter 4 – Code of safe working practices (pg 87)

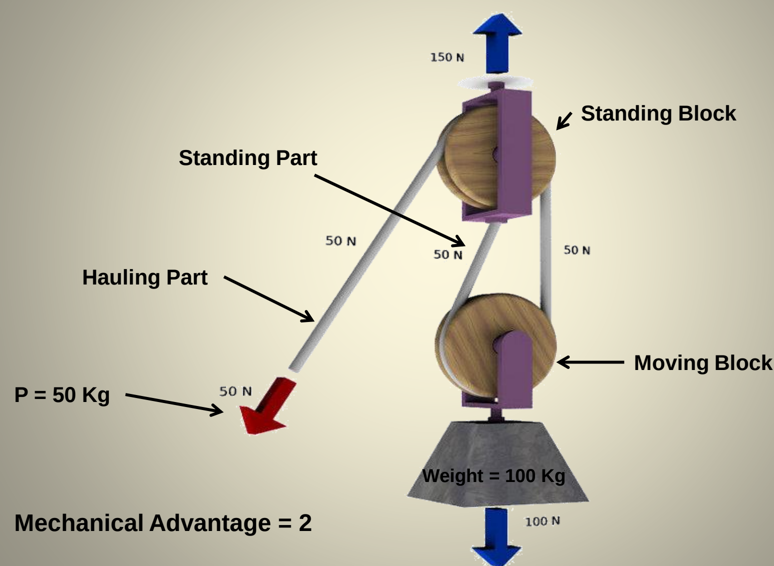


Online Resources
Hydraulics - https://en.wikipedia.org/wiki/Hydraulic_machinery

Lifting Principles - https://www.worksafeconnect.com/guide-for-doggers.pdf

98

Purchase And Tackles



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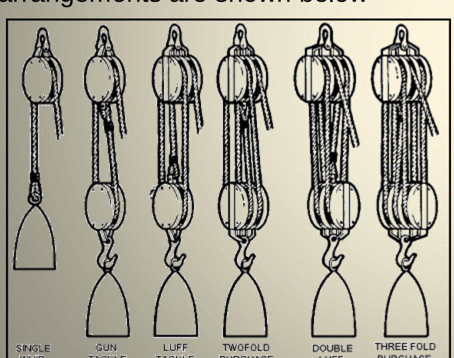
Mechanical Advantage

Types Of Purchases Or Pulley Systems

The aim of rigging purchase arrangements is to reduce the final effort on a person or winch when lifting or hauling loads. The ratio of load over final effort required is known as mechanical advantage. Some common types of pulley arrangements are shown below



- Single Whip – a single block that does not offer any mechanical advantage.
- Gun Tackle – a one fold purchase.
- Luff Tackle – consist of unequal number of sheaves in the two blocks, luff shown is 2 and 1, double luff shown is 3 and 2, and so on.
- Two Fold purchase – consists of two x 2 sheave blocks
- Three Fold purchase – consists of two x 3 sheave blocks
- A Four Fold purchase – consists of two x 4 sheave blocks, and so on

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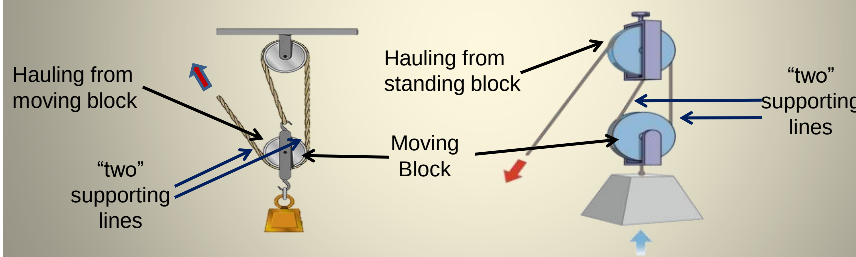
Mechanical Advantage

How to determine Mechanical Advantage

To calculate the mechanical advantage of a purchase, count the number of lines (or falls) that support the moving block. In this example, the moving block is supported by “two” lines in both cases, so we have MA of 2 in both instances.



Next, we must then determine if you are rigged to either “Advantage” or “Disadvantage”

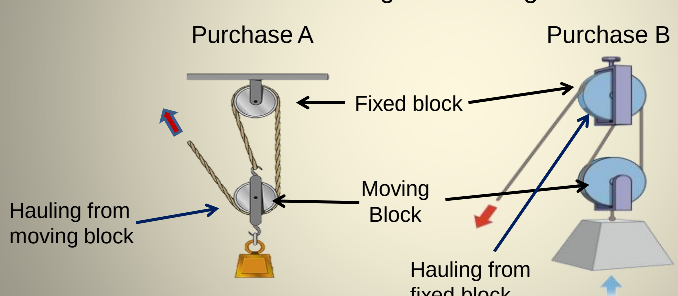
Lets look at that next

101

Mechanical Advantage

How to determine Mechanical Advantage

Every purchase can be rigged in two ways, with either the hauling line coming out of the fixed block or the hauling line coming out of the moving block



When the hauling line is coming out of the moving block, the purchase is said to be “rove to advantage” as the hauling line is assisting in the lift. The purchase is thus given an additional one (1) to add to the mechanical advantage.

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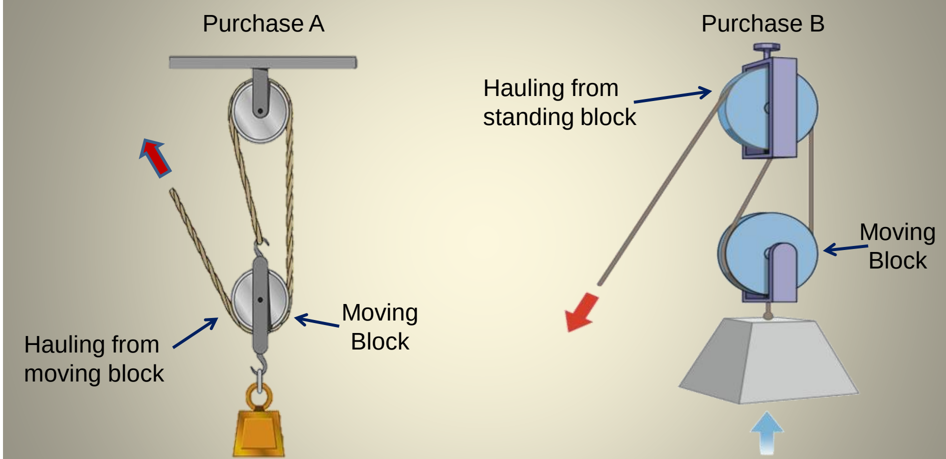
Mechanical Advantage



Purchase A is rigged to “Advantage” *(Number of supporting lines = 2)* ***+1*** *{as line hauling from moving block} thus* ***MA = 3***

Purchase B is rigged to “Disadvantage” *(Number of supporting lines = 2){as line hauling from standing block} thus* ***MA = 2***

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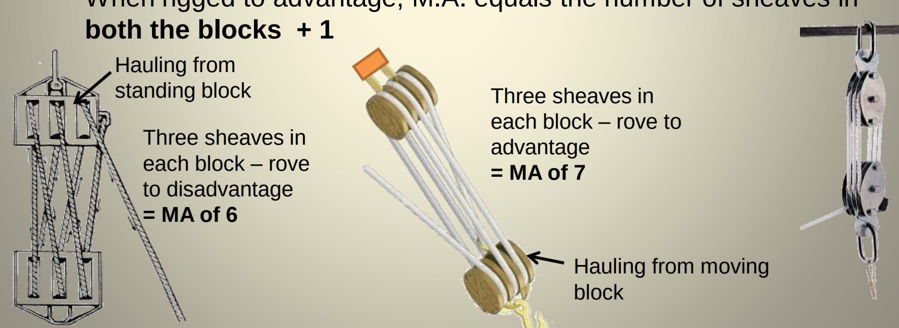
Mechanical Advantage

Another method of calculating mechanical advantage

- Another method of calculating mechanical advantage (and maybe simpler to understand) follows;
  - When rigged to disadvantage, M.A. equals the number of sheaves in **both the blocks**
  - When rigged to advantage, M.A. equals the number of sheaves in **both the blocks + 1**



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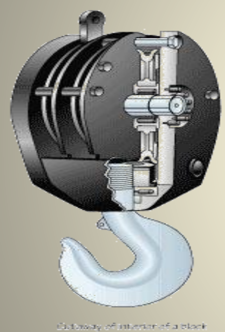
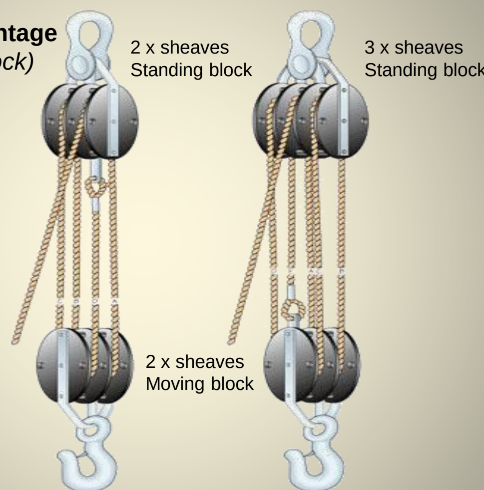
Mechanical Advantage

Both systems rove to **disadvantage**
(hauling from standing block)





Two fold purchase (4 ropes supporting moving block) or 4 sheaves in both blocks
= MA of 4

Gyn Tackle (4 ropes supporting moving block) **but** 5 sheaves in both blocks
= MA of 5

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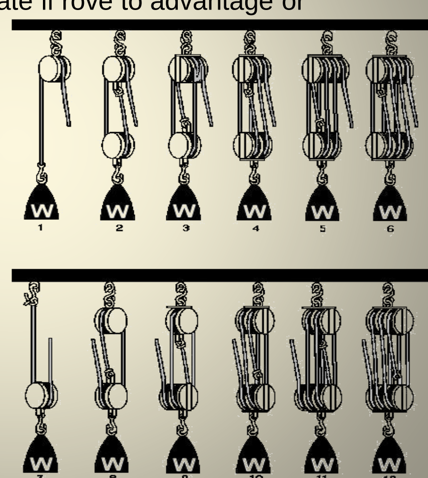
Mechanical Advantage

- Exercise
  - Test yourself! Can you name each pulley type, the mechanical advantage gained and indicate if rove to advantage or disadvantage, 1 through 12



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Mechanical Advantage

Some Additional Notes

- Most purchases are rigged to disadvantage simply because it is easier to physically pull a line downwards rather than upward. The load can also be lifted to a greater height
- **Most importantly**, the **SWL of Blocks, Hooks and Shackles must be equal to the entire load**. They do not gain from the mechanical advantage of the purchase.

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OH&S And Legislation

- Any vessel using slings, shackles, chain for lifting or securing cargo must have a lifting equipment register
- All Slings and Chain used for lifting must be **tested** every 12 months and a certificate issued by an approved person/company
- All Slings, Shackles and Chain used for lifting must be visually **inspected** and tagged every 3 months and logged by a competent person onboard
- Every crane and lifting boom/ Derrick must have a SWL marked on it and be tested every 5 years.
- Marine Orders Part 32 covers all cargo lifting and securing equipment

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OH&S And Legislation

A little about the Regulation, Marine Orders Part 32

- All cargo handling gear, including cranes, must comply with Commonwealth regulations contained in Marine Orders Part 32.
- All fixed gear, such as cranes and derricks, must be periodically tested and maintained as per manufacture's instructions.
- Cordage (fibre ropes) in constant use should be examined every 6 months.
- Wire ropes in constant use should be examined every 3 months.
- All lifting gear should be opened up and examined annually.
- Vessels crew must inspect and maintain the gear.
- You must keep an accurate record of these inspections and maintenance.
- Commercial vessels fitted with cargo lifting gear must maintain an AMSA approved inspection and maintenance register for lifting gear, commonly known as the *Chain Register*.

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OH&S And Legislation

A little about the Regulation, Marine Orders Part 32

Main points for us to remember.

- Marine Orders Part 32 covers lifting and securing work on a vessel.
- All Slings and Chain used for lifting must be **tested** every 12 months.
- All Slings, Shackles and Chain used for lifting must be visually **inspected** and tagged every 3 months.
- Cranes, lifting booms and derricks must be inspected and tested every 5 years.
- These regulations also apply to all cargo lashing equipment including straps and fittings.
- The SWL is to be marked on all lifting and lashing gear.
- An AMSA approved inspection and maintenance register for lifting gear (*Chain Register*) must be kept on the vessel.

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OCCUPATIONAL HEALTH & SAFETY

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OH&S And Legislation

- Always conduct pre start checks before using any deck equipment and check for faults.
- Always use the correct PPE, and carry out a risk assessment before starting the work.
- Don't operate deck equipment if you are not trained to use it
- Always perform a dry run without a load before lifting any weight
- Always check stability before lifting any weight with an on board lifting device
- Never pass loads over personal

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OCCUPATIONAL HEALTH & SAFETY

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OH&S And Legislation

- Never leave loads suspended and the controls unattended
- Always be aware of sudden failure of hydraulics and electrics
- Make sure that maintenance is carried out according to the planned maintenance regime and recorded
- Tag out and isolate any equipment found faulty.
- Always test mechanical lifting devices with a load after repair before putting it back into service
- Any lifting gear found to be defective should always be isolated and reported to Master, Engineer or other responsible person per operational procedures.

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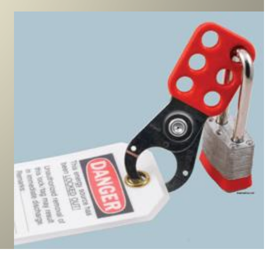
PPE

When working with any deck equipment including winches, cranes and derricks, always use correct PPE

- Gloves,
- Hard Hat
- Strong shoes, possible steel toe caps
- Glasses
- Face shield
- Lock out tags
- MSDS sheet for hydraulic oil in use
- Spill kit



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Working Aloft Or Over The Side

From the "Code Of Safe Working Practices For Australian Seafarers" (AMSA)

AMSA has certain provisions that apply to working aloft or over the side of a vessel, and these guidelines should be included in a vessels SMS. Procedures should include, but not limited to the following:

When working over the side

- Should wear a safety harness
- Have restraints appropriate to conditions
- Safety nets rigged where necessary
- Should wear a life jacket or other floatation device
- Have a lookout on deck
- Lifebuoy and line readily available
- Tools not carried in pockets
- Tools secured with a lanyard
- Gantline {line used to hoist persons} inspected
- Rope ladders should be in good condition and properly secured
- Ropes, stages and bosun's chairs to be stored in a special locker not used for any other purpose
- Ships whistle, funnel, radio aerials and radar scanners to be isolated

Additionally, when aloft:

- Inspect all lines and fittings
- Load test to 4 to 5 times the load
- Wear a safety harness

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Working Aloft Or Over The Side

General procedures and precautions to be taken

- Consult the vessels SMS which should include details regarding working aloft or over the side of the vessel.
- Clear the area of any non essential equipment, loose lines and debris.
- Always carefully inspect lifting equipment and any stages etc. before use.
- Use safety equipment and PPE as prescribed. Always test for functional operation before use.
- Use portable ladders with caution, they can become unstable with vessel movement. Never over-reach on portable ladders.
- Carry out specific tasks as detailed in the procedures section of the vessels SMS
- After use, inspect all equipment, carry out any required maintenance and correctly store away per the code of practice.

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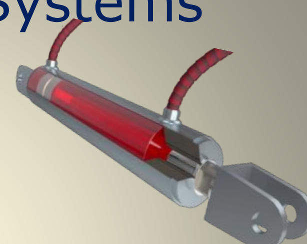
Simple Hydraulic Systems

Simple Overview



The purpose of a specific hydraulic system may vary, but all hydraulic systems work through the same basic concept. Defined simply, hydraulic systems function and perform tasks through using a fluid that is pressurized. Another way to put this is the pressurized fluid makes things work.

The power of liquid fuel in hydraulics is significant and as a result, hydraulic are commonly used in heavy equipment. In a hydraulic system, pressure, applied to a contained fluid at any point, is transmitted undiminished. That pressurized fluid acts upon every part of the section of a containing vessel and creates force or power. Due to the use of this force, and depending on how it's applied, operators can lift heavy loads, and precise repetitive tasks can be easily done.

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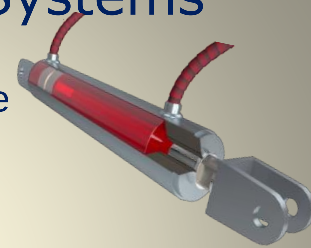
Simple Hydraulic Systems

The principle of hydraulics is simple



- The amount of flow gives speed
- The amount of pressure gives force
- A pump gives both the flow and the pressure therefore selecting too small a pump won't give the flow required nor the pressure expected.
- If the pressure in the system is to great the components will fail, so don't tighten down the pressure relief valve to make the system work faster or do more things.
- If in doubt call in the experts
- When it fails it's sudden and often with no warning

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Simple Hydraulic Systems

Hydraulic Circuits

Transporting liquid through a set of interconnected discrete components, a hydraulic circuit is a system that can control where fluid flows, as well as control fluid pressure.

The system of a hydraulic circuit works similar to electric circuit theory, using linear and discrete elements. Hydraulic circuits are often applied in chemical processing (flow systems).

Mechanical power is converted into hydraulic energy using the flow and pressure of a hydraulic pump. Hydraulic pumps operate by creating a vacuum at a pump inlet, forcing liquid from a reservoir into an inlet line, and to the pump. Mechanical action sends the liquid to the pump outlet, and as it does, forces it into the hydraulic system.

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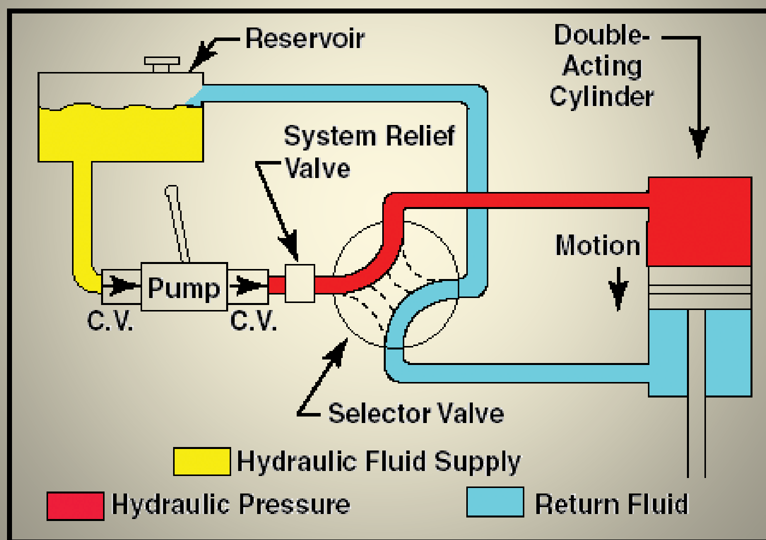
Simple Hydraulic Systems



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Hydraulic Pumps

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Hydraulic Pumps

Hydraulic pumps supply fluid to the components in the system. Pressure in the system develops in reaction to the load. Hence, a pump rated for 5,000 psi is capable of maintaining flow against a load of 5,000 psi.

Pumps have a power density about ten times greater than an electric motor (by volume). They are powered by an electric motor or an engine, connected through gears, belts, or a flexible elastomeric coupling to reduce vibration.

Common types of hydraulic pumps to hydraulic machinery applications are;

Gear pump: cheap, durable (especially in g-rotor form), simple. Less efficient, because they are constant (fixed) displacement, and mainly suitable for pressures below 20 MPa (3000 psi).

Vane pump: cheap and simple, reliable. Good for higher-flow low-pressure output.

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Hydraulic Pumps

Axial piston pump: many designed with a variable displacement mechanism, to vary output flow for automatic control of pressure. There are various axial piston pump designs, including swashplate (sometimes referred to as a valveplate pump) and checkball (sometimes referred to as a wobble plate pump). The most common is the swashplate pump. A variable-angle swashplate causes the pistons to reciprocate a greater or lesser distance per rotation, allowing output flow rate and pressure to be varied (greater displacement angle causes higher flow rate, lower pressure, and vice versa).

Radial piston pump: normally used for very high pressure at small flows.

Piston pumps are more expensive than gear or vane pumps, but provide longer life operating at higher pressure, with difficult fluids and longer continuous duty cycles. Piston pumps make up one half of a hydrostatic transmission.

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Switchboard Control

123

Hazards Of Hydraulics

Hydraulic oil is pumped under very high pressure and becomes extremely hot and dangerous.

- Keep a constant check on all fittings and hoses
- Never touch a pressurised hose (risk of injection injury)
- Look for bulges in hoses and around terminations
- Spray oil from a failed hose is very hot and will burn on contact
- Hoses will whip under high pressure following a rupture
- Slip hazard from leaking hydraulic fluid on decks and floor spaces
- Be aware of pollution risks from oil leaks within the system
- Never adjust the pressure relief valve outside of manufactures recommendations

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Hazards Of Hydraulics

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Danger of hydraulic Oil Injection Injuries

Did you know that a pinhole leak in your hydraulic hose can release hydraulic fluid with enough pressure to penetrate both clothing and skin?

Employees can become complacent around hydraulic systems and that is when mistakes are made, maintenance is neglected and injuries occur. While most common injuries may be just a result of slip and fall, three more serious dangers exist: burns from hot hydraulic fluid spray, injuries sustained from falling or whipping hydraulic lines and injection of hydraulic fluid into the skin.

A hydraulic fluid injection is perhaps the most dangerous injury that can result from a hydraulic hose failure. One reason is that it can appear benign at the beginning so it often gets dismissed as not urgent and medical care is postponed. Another reason is that injected hydraulic oils are highly toxic - so in addition to a physical cut or stab, they literally poison you.

The most important things to remember: NEVER touch a pressurized hose with your hand and if you suspect an injection injury has occurred, get to an emergency room right away!

126

Study Note

- Describe what a Bosun's chair and a gantline is. When would you use these? How should they be stored?
- You have been given a task that involves working over the side of your vessel. Where might you find information on how you should prepare for your work?

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Winches

We previously discussed anchor windlasses and capstans in the Anchor Systems module, in this module we will look specifically at winches used for handling weights such as cargo and fishing gear.

These winches can be classified as Conventional Drum Winches or Traction Winches.

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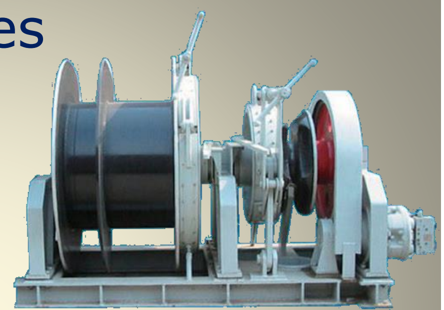
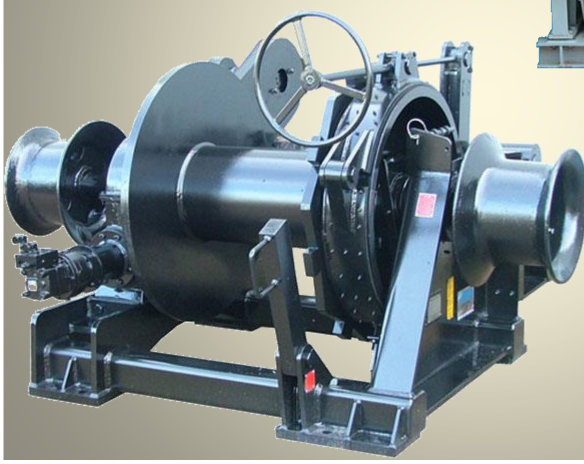
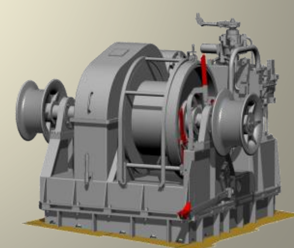
Winches

- Used to haul wires or ropes
- Electric, Hydraulic or PTO driven
- Exposed to harsh environment







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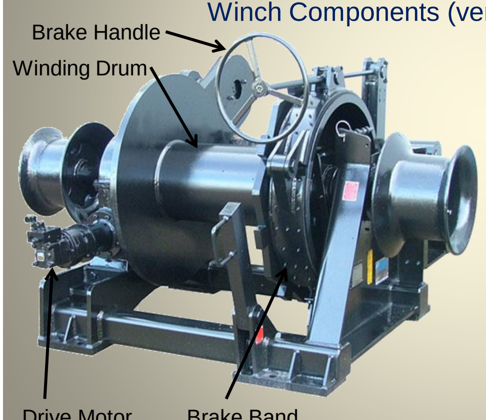
Winches

Depending on the type of vessel, small cargo vessels are likely to be fitted with swinging derricks that may be controlled by luffing and head winches or in more recent times hydraulic cranes. Some form of winch is a major component of most fishing operations.

Winch Components (very similar to windlasses)



- Winding drum (winch barrel) fixed to a shaft, usually between two bearings.
- Brake drum secured to the winding drum, with brake band
- Brake handle controls brake band tension.
- Electric or hydraulic motor coupled to one end of the shaft (usually with a solenoid operated brake)
- Usually includes a remote control unit to enable operation at the winch.

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Winches

Routine Maintenance

WEEKLY

- Grease fittings
- Operate clutch through full travel
- Operate windlass
- Check oil levels
- Check emergency stops
- Check Brake operation

6 MONTHLY

- Inspect clutch plates for wear/corrosion
- Inspect mechanical brake for wear
- Inspect winch base/mountings for corrosion

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Winches

Safety Precautions

All gear used for cargo handling on commercial vessels is subject to safety legislation in relation to inspection and testing schedules and stamping of working load limits (WLL). Cargo is not to be lifted by defective gear or dragged, lifted or in any way moved if there is a risk that the WLL of any component could be exceeded.

Warping Drum and Winch safety measures may include:

- Maintain gear in good condition
- Testing winch controls prior to use
- Knowing the position of the emergency stop
- Normally passing only three turns around a warping drum
- Tailing at least half a meter back from the drum
- Surging (non-synthetic lines only) in a controlled manner
- Keeping area clear of unnecessary persons
- Wearing safety footwear
- Ensuring unobstructed view and good lighting

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Winches

Safety Precautions

Warping Drum and Winch safety measures may include:

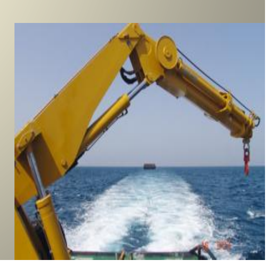
- Avoiding riding turns
- Avoiding manual barring (fit proper warp guides)
- If barring is required, ensuring a second operator on the controls
- Avoiding greasing a warp being heaved under loads (keep clear)
- Avoiding loose clothing and loose hair
- Leaving a minimum of two turns on the drum
- Providing winch guards wherever possible
- Operating winches smoothly
- Avoiding leaving loads suspended
- Securing wires to winch drums by some means other than a fibre tail
- Ensure that the wire (runner) on the winding drum is securely fastened to the drum

133

Cranes And Derricks

Some cranes allow 3 motions:

- Lifting
- Slewing (turning)
  - The rotary motion of the crane, boom or load in a horizontal plane
- Luffing (raising or lowering jib boom)
  - Means changing the elevation angle of the crane boom/jib



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Crane And Winch Maintenance

Weekly

- Check winch brake for correct operation
- Inspect brake lining for wear and grease deposits
- Operate davit boom through its operating arc by manual slewing
- Operate winch with a dummy load

135

Crane And Winch Maintenance

Monthly

- Lubricate/Grease all points on the crane
- Inspect brake lining for wear and grease deposits
- Check oil levels
- Clean all wire ropes
- Oil linkages that don’t have grease points
- Examine wire ropes for broken strands and kinks and lubricate running gear

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Crane And Winch Maintenance

Six Monthly

- Check manual lifting clutch, brake assembly and gearbox clutch for damage, wear and oil contamination
- Examine every part for corrosion, distortion, cracks or any other defects
- Check slewing gear for backlash
- Check cranes certificates are current
- Check SWL rating plate is legible

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Precautions In Deck Machinery Operations

- Check Vessel Stability before any lift
- Ensure controls are clearly marked
- Ensure operators are properly trained
- Only operate equipment per manufactures instructions
- Never exceed the rated SWL
- Do not operate with faulty brake or clutch or damaged parts
- Moving parts (gear wheels) to be covered at all times
- All guards correctly fitted and in place

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Precautions In Deck Machinery Operations

- Keep work area free from oils and grease
- Do no operate if load cannot be seen if working without a dogman
- Know how to stop in an emergency
- Know where the emergency stops are located
- Always carry out inspections at appropriate intervals
- Use appropriate PPE

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Precautions In Deck Machinery Operations

Overview

- Operators trained and instructed in use
- Machinery not to be operated beyond SWL
- Operating controls clearly marked
- Guards in place, Emergency stops working
- Check operation before lifting load (dry run)
- Check all blocks, shackles and wire rope
- Work area free from oil/grease
- Don’t pass loads over personal
- Don’t leave loads suspended and unattended
- If found faulty don’t use tag out, defect report, fix if possible.
- Regular maintenance, grease, oil, check fixings, check for leaks and damaged hoses

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Precautions In Deck Machinery Operations

If Winch or Crane fails with a suspended load

- Secure the load
- Secure the area
- If fitted with emergency lowering device slowly lower the load back to the deck
- Depending on the fault, for example a problem with the slew function of the crane, lowering might be possible if there is no risk of the load crashing to the deck.
- Lock out and tag out.

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Safety Precautions Using Lifting Gear

When using lifting gear around a vessel, the following precautions should be taken to maximise safety;

- Carefully examine all gear immediately before use:
  - Ensure safety chains for overhead gear is provided
  - Ensure wire guides are provided where required
- Service and renew gear as necessary
- Trim the vessel on an even keel.
- Ensure the vessel's vertical stability remembering that the use of cranes will raise the vessel's centre of gravity.
- Minimise free surface effect
- Ensure fore and aft lines are tight and that breast lines are slackened to allow some free heel.

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Safety Precautions Using Lifting Gear

When using lifting gear around a vessel, the following precautions should be taken to maximise safety;

- Rig load control lines and guys
- Ensure trained and competent operators
- Lift slowly and smoothly
- Ensure adequate lighting
- Provide fences to open hatches and access areas
- Avoid leaving loads suspended
- Adhere to SWL guidelines (including when slinging)
- Ensure personnel are outfitted with personal protective equipment

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Safety Precautions Using Lifting Gear

Exercise

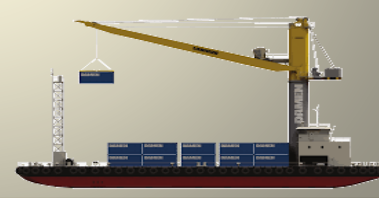
As the officer on watch, you have been assigned the task of overseeing the loading of stores onto your vessel. You will be using the ships crane. What will be your procedures and checks?

- Consult the vessel SMS for procedure information.
- Check the chain register for latest details on lifting gear
- Determine the weights of items to be lifted
- Check crane SWL and the SWL of all equipment, slings, chains and shackles
- Complete a visual inspection of slings, chains shackles for damage
- Complete a risk assessment
- Complete a pre-start check of crane
- Perform a dry run before lifting using all motions
- Check vessel stability

144

General Lifting Precautions

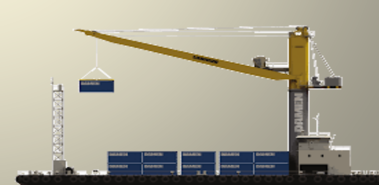
- The operator must not pass a loaded boom over personnel.
- All motion with heavy weights should be slow to avoid creating momentum.
- Heavy weights should never be allowed to drop no matter what the distance.
- Never keep a load in the air any longer than necessary.
- Avoid swinging the load. If you're lifting something off a wharf, be sure it is positioned directly under the head of the crane or boom before lifting.
- Attach steady lines to all loads.
- Avoid sudden shocks or strains, and be aware of side pulls. These put great stress on a boom or crane.



145

General Lifting Precautions

- Stay out from under booms and cranes while lifting operations are in progress.
- Don't stand between a load in the air and a rail, stanchion, hatch coaming or any solid object against which you could be crushed.
- Never use running gear as a handhold.
- Listen for changes of sound in a wire, rope or block. Wire or cordage normally hums under strain. If it starts to squeak or squeal, watch out. A faulty block may give warning by squeaking or groaning



146

Recommended Crane Signals

Signals

Code of Signals For Working Cranes or Derricks

- Whenever signals are needed to guide a crane driver, those in the diagram over page should be used.
- Only one person signals a driver at a time, however the driver should obey anyone who gives the 'STOP' signal as this may indicate an emergency.
- High visibility gloves or armbands may be worn by the signaler to show his/her authority and to make the signals clear.

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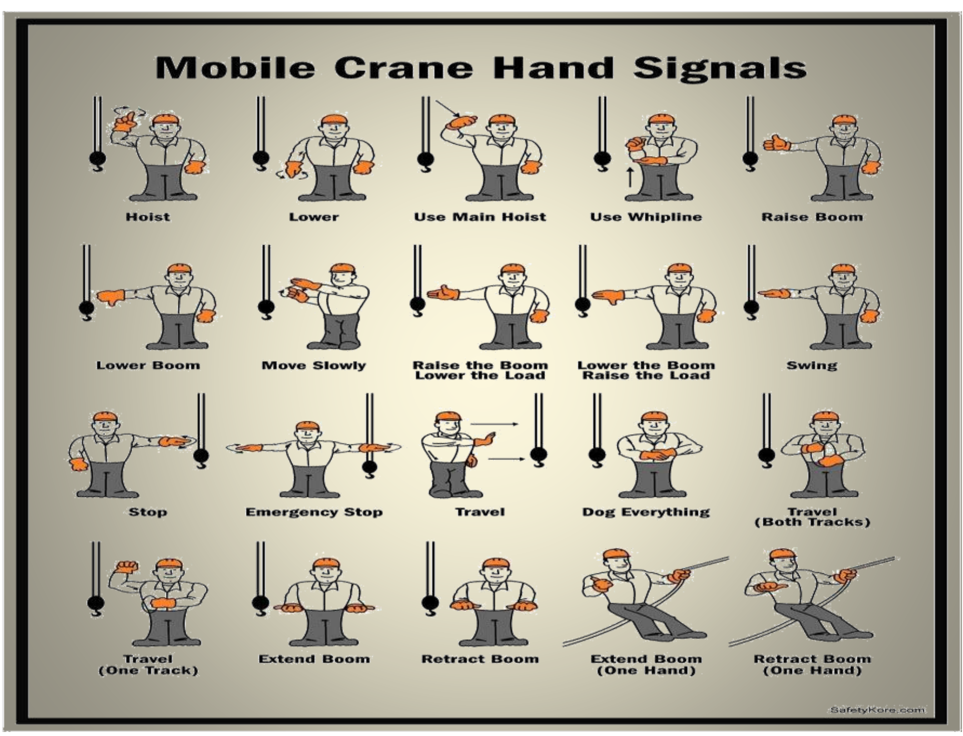

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Survey Requirements

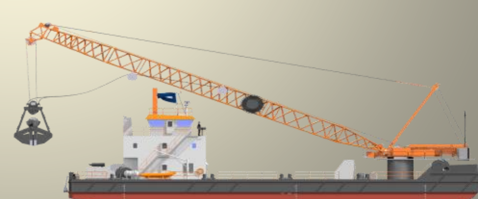
- Cranes and Derricks are load tested and thoroughly examined every 5 years and certified with SWL limits
- Operators responsibility to ensure equipment is operated within safe limits, never exceeding SWL's
- Slings, chains and shackles tested yearly and certified
- Slings, chains and shackles inspected every 3 months and tagged
- Deck mountings, fittings, deck plating and anchor points inspected annually for corrosion, fatigue and distortion.

NOTE
Any gear used for handling cargo must comply with Commonwealth Regulations contained in Marine Orders 32 *(Cargo and Cargo Handling – Equipment Safety Measures)*

149

Use and maintain deck machinery and equipment records

- All Deck Machinery must have pre start checks before use (OH&S) and records kept (Check Lists)
- Regular Planed Maintenance (monthly Checks)
- Annual inspection at Survey
- SWL test and certificate every 5 Years (Cranes)
- Lifting equipment Register 12 monthly certificates on slings, shackles, chains etc.
- 3 Monthly visual inspection and tag items, everything used for lifting operations, Slings, Shackles, Chains, Wire Strops



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Safety Management System — Form: MAR-DEC-001

DECK EQUIPMENT CHECKLIST

Vessel:	Monthly checks	Date:		
	EQUIPMENT	YE	N	**COMMENTS**
1	**Windlass:**			
	Controls and signage			
	Brakes bands and control arm			
	Clutch mechanism and linkage			
	Cable and linkages			
	Foundation support			
2	**Fwd winches:**			
	Controls and signage			
	Brake band and control arm			
	Clutch mechanism and linkage			
	Wire/Synthetic Rope condition			
	Sheaves/fairleads and capstans			
3	**Forecastle:**			
	Doors, hinges and closing assembly			
	Rubber seals			
	General area condition/cleanliness			
	Lighting (240v)			
4	**Fore Deck / Main Deck:**			
	Breathers (including gauzed openings)			
	Hydraulic pipes & hoses			
	Freeing ports / scuppers			
	Sounding points (for damage)			
	Paint condition			
	Deck condition			
	Working lights			
	3 Phase outlets			
	Doors, hinges and closing assembly			
	Fuel points & hoses (within test dates)			
	Cargo equipment (chains/straps ___)			
5	**Accommodation area:**			
	General condition/cleanliness			
	Doors, hinges and closing assembly			
	External signage (Muster, Fire Flap __)			
	External lighting (24/240v)			
	Internal lighting (24/240v)			
	Internal amenities (showers ___)			
	White goods (fridge, freezers ___)			
	Emergency exits (clearly marked and visible without lights [luminescent stickers])			

Document No: Deck check-001
Revision No: Version 1
Reviewed On: 27th Apr 2011 Printed Documents are Uncontrolled Page 1 of 2

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Study Note

- Your vessel has a crane, lifting equipment, and cargo securing devices and lashing equipment on board. What records would you maintain and where would you keep these records?
- Do you need to arrange for your lifting equipment to be inspected and or tested? If so, how often would you arrange this?

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Thankyou

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ECA Maritime College

ANCHOR SYSTEMS

154

ANCHOR SYSTEMS

On completing this session

You will

- ✓ Understand the difference between a Windlass and a Capstan
- ✓ Explain the component parts of a windlass
- ✓ Describe Windlass Maintenance
- ✓ Be able to choose a safe anchorage
- ✓ Be able to determine the best type of anchor to use in different situations
- ✓ Describe how to deploy an anchor
- ✓ Understand how a sea anchor is deployed
- ✓ Explain what anchor scope is and how to determine correct scope
- ✓ Demonstrate how to set multiple anchors

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ANCHOR SYSTEMS

Common Terms used in this session

A windlass – Is a mechanism for controlling an anchor rode as it is let out or hauled in

Anchor aweigh – The anchor is aweigh immediately it is broken out of the ground.

Bitts – Are deck fixtures comprised of strong uprights (usually metal) to which an anchor rode could be secured.

Bitter end – The bitter end is the part of the cable aft of the bitts.

Bow roller – The bow roller is a device over which the anchor rope or chain rolls freely.

Brought up – When the cable is taut between vessel and anchor.

Catenary – The curve formed by a uniform chain hanging freely from two points not in one vertical line.

Chain stopper – A devise, usually permanently fitted in place, used to take the strain off the windlass (for example, a devils claw)

Clear anchor – When the anchor is unencumbered and has not picked up its own cable, chain or wire. Otherwise, the anchor is foul.

Devil's claw – See chain stopper.

Foul anchor – The anchor has fouled on an obstruction.

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ANCHOR SYSTEMS

Common Terms used in this session

Hawse – The part of a vessel's bow where the hawse holes and the hawse pipes are situated.

Hawse hole – Is a well faired opening in a bulwark through which a rode (or hawser) may pass.

Hawse pipe – These are cast steel pipes near the bow of a vessel, between upper deck or forecastle and the vessel's side through which a cable passes and into which the shank of an anchor may be drawn.

Hawser – A heavy line or cable used for towing, mooring or anchoring a large vessel.

Rode – The anchor line or cable between the attachment on the vessel and the anchor.

Scope – The ratio of the cable out to the depth of water when vessel rides at anchor.

Short or long stay – The cable is at a short stay if it leads steeply downwards from the hawse pipe and at long stay if it leads well away and less steeply.

Snub – To break sharply.

Spurling pipe – A deck fitting through which the chain or rope passes into the locker.

Veer – To use power in paying out the cable and not let it run free.

Weigh anchor – To heave in cable until the anchor is broken out of the ground and clear of the water.

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ANCHOR SYSTEMS

Recommended Study Reference

Small Ships Training and Operational Manual – Edition 6
Maritime Safety Queensland
Chapter 26 – Anchoring

Australian Boating Manual
Capt. Dick Gandy
Chapter 7 – Anchoring Systems

Grab a coffee and go online and check out the following, entitled "Top 5 Anchor Drop Failures". The clip is around 10 minutes and apart from the failures, you do get a good look at chains and markings etc. Enjoy!

https://www.youtube.com/watch?v=hMytHt1D1go

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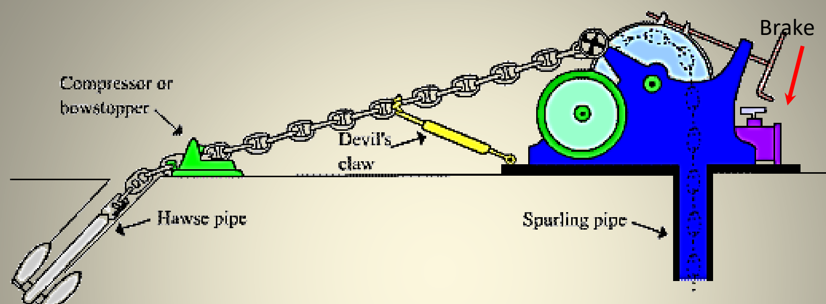
Anchor Windlass



- For handling anchor chain
- Usually located in exposed position, well forward on bow
- Many moving parts enclosed
- Requires routine maintenance (grease) check oil in gearbox, check brake bands and clutch
- Check fixings, check hydraulic hoses for leaks and chafe, check electric motors for water ingress

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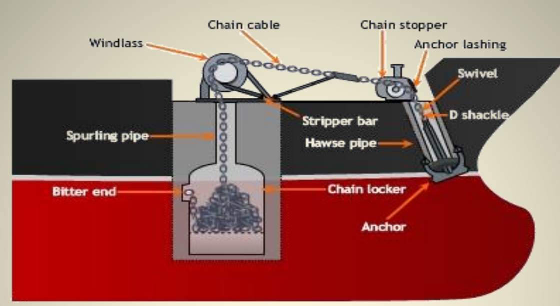
Anchor Windlass



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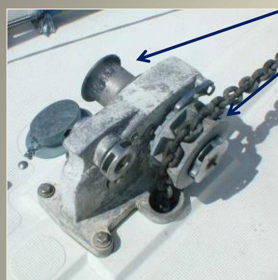
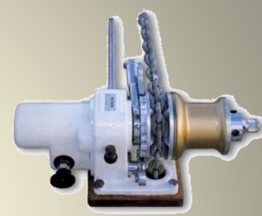
Anchor Windlass



Capstan or warping head

Gypsy

"Windlass"
Drive Spindle
Horizontal



A windlass incorporates a horizontal drive spindle

The windlass is used to control an anchor rode as it is let out or hauled back in. Most windlass units will have both a capstan, or warping head, and a gypsy which controls the anchor chain.

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Anchor Capstan

Capstan or warping head

Gypsy

"Capstan"
Drive Spindle
Vertical

A Capstan incorporates a vertical drive spindle

The capstan is essentially the same as a windlass but incorporates a vertical spindle, and is also used to control an anchor rode as it is let out or hauled back in.
Most capstan units also have both a capstan, or warping head, and a gypsy which controls the anchor chain. In the case of a capstan, the gypsy is most often positioned below the capstan, or warping head.

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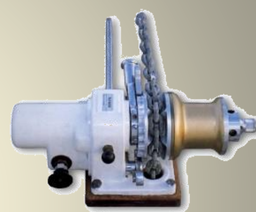
Anchor Windlass and Capstan



"Windlass"
Drive Spindle
Horizontal

"Capstan"
Drive Spindle
Vertical

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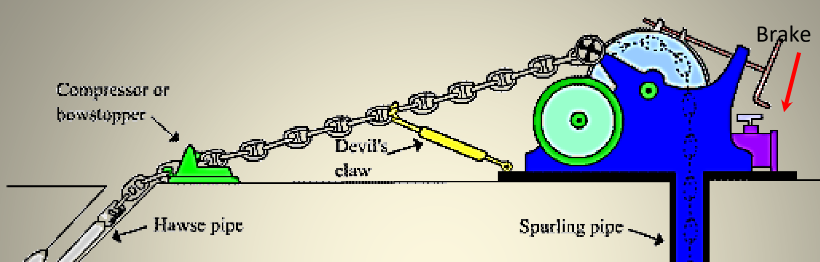
Anchor Windlass



Windlass Vs Capstan Confusion

A Capstan (complete unit) is a drum that revolves around a vertical shaft. Right?

A Windlass (complete unit) consists of one or more drums operating on a horizontal shaft. Right?

But as we have just learnt, a windlass also has a drum on it called a capstan?? What The ???

The "capstan" on a windlass is also known as a warping head (used for moving a vessel along a wharf by heaving on mooring lines without using the engines) Don't be confused in the terminology.

Quite often, the marine industry refers to the complete units as "vertical" and "horizontal" windlasses to describe each in an effort to take away some of the confusion

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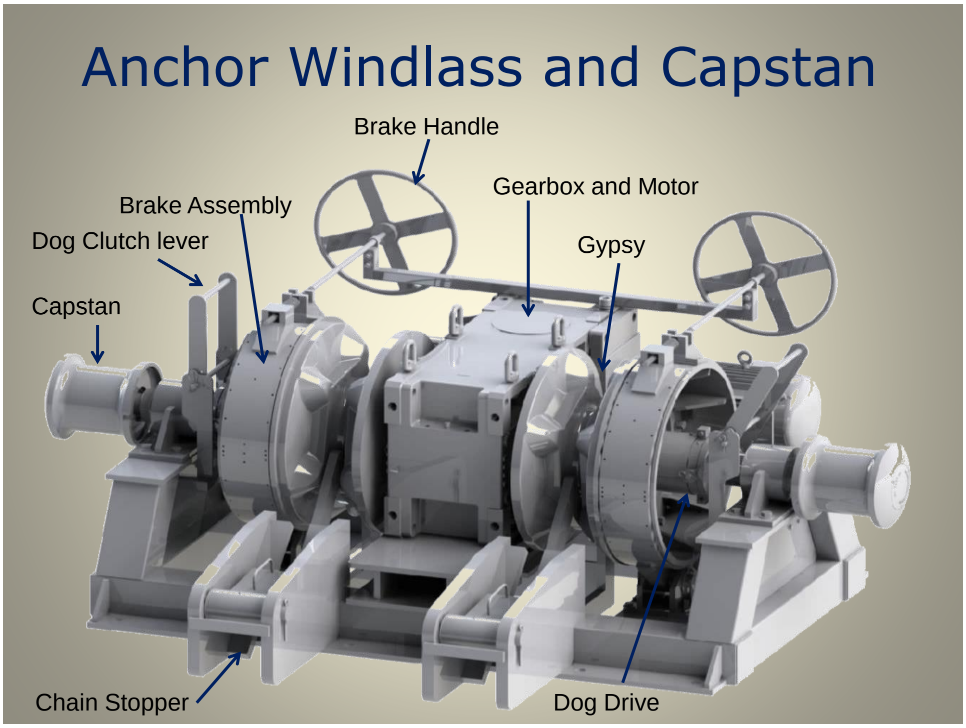
Anchor Windlass and Capstan
Brake Handle
Gearbox and Motor
Brake Assembly
Dog Clutch lever
Gypsy
Capstan
Chain Stopper
Dog Drive

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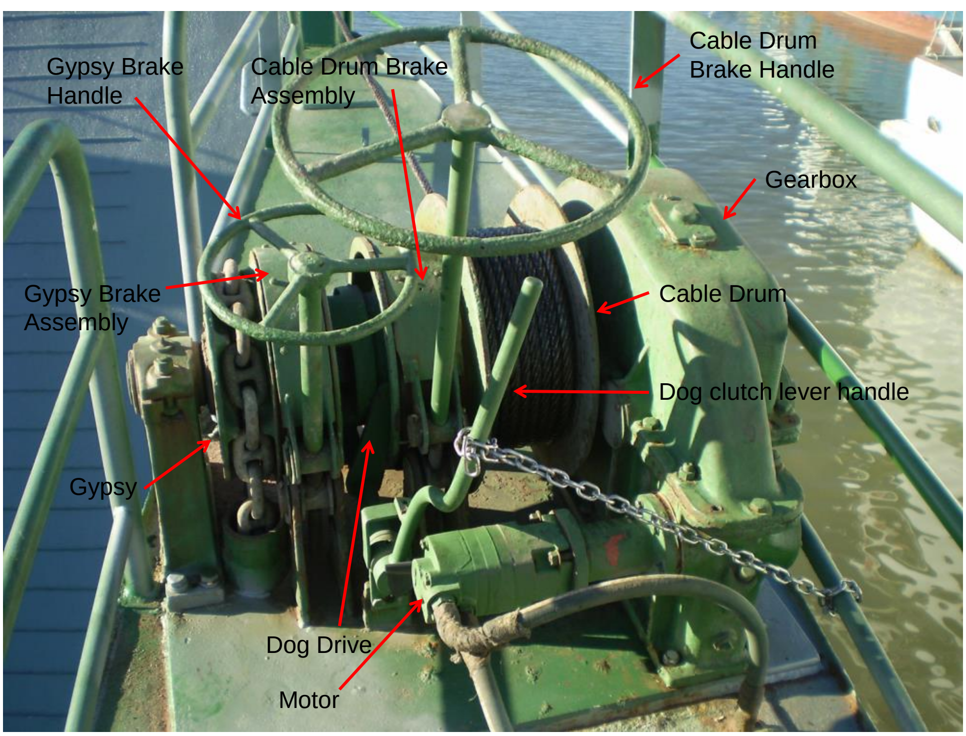
Gypsy Brake Handle
Cable Drum Brake Assembly
Cable Drum Brake Handle
Gearbox
Gypsy Brake Assembly
Cable Drum
Dog clutch lever handle
Gypsy
Dog Drive
Motor

166

Anchor Windlass Maintenance

WEEKLY

- Grease fittings
- Operate clutch through full travel
- Operate windlass
- Check oil levels
- Check emergency stops
- Check Brake operation

6 MONTHLY

- Inspect clutch plates for wear/corrosion
- Inspect mechanical brake for wear
- Inspect winch base/mountings for corrosion

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Selecting an Anchor

Types of Anchors

Admiralty pattern anchor (Kedge anchor)

Standard stockless anchor

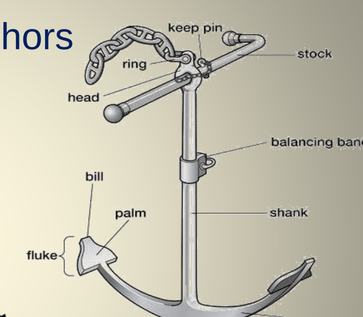
CQR anchor (Plough anchor)

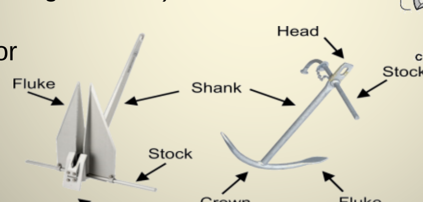
Danforth anchor

Bruce anchor

Reef anchor

Sea anchor





Lets take a look at each anchor in greater detail

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Selecting an Anchor

Types of Anchors

Admiralty pattern anchor (Kedge anchor)

Was once considered by many mariners to have the greatest holding power, weight for weight, for all types of bottoms. Today however, many modern anchors are superior in this respect.

The anchor holds as the stock rests horizontally on the bottom and as the flukes are set at right angles to the stock, the lower fluke digs in to the bottom and holds.

Advantages
- Good holding power

Disadvantages
- Cannot be stowed in a hawse pipe so must be stowed on deck
- Is a large anchor and may be difficult to handle and stow

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Selecting an Anchor

Types of Anchors

Standard stockless anchor

This anchor is often used by steel trawlers and larger vessels. The anchor as no stock and therefore can be hove tight home in the hawse pipe.

Anchor holds as it is dragged along the bottom and the weight of the flukes and the design of the tipping palm force the flukes downward to dig into the bottom.

Advantages
- No stock so stows well in the hawse pipe with flukes flat against hull
- Greater holding power compared to the Admiralty anchor

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Selecting an Anchor

Types of Anchors

CQR anchor (Plough anchor) *Considered a good choice for mud bottom applications*

The CQR anchor is a hot forged anchor of extreme strength, and has excellent holding power.

Generally used on smaller vessels as it is difficult to stow in a hawse pipe, but works very well with a bow roller system.

Advantages
- Excellent anchor in all types of sand, mud and clay
- Very strong construction
- Rarely fouls and will reset if direction of strain or pull changes

Disadvantages
- Has difficulty penetrating heavy weed cover
- Impossible to stow in a hawse pipe
- Difficult to stow on deck

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Selecting an Anchor

Types of Anchors

Danforth anchor *Considered a good choice for sand bottom applications*

Good general purpose anchor for small vessels such as coastal and inshore fishing vessels. Has good holding power given its weight. Resembles a lightly built stockless anchor in appearance and method of operation.

Advantages
- Will stow into a Hawse pipe
- Easy to stow on deck
- Economical

Disadvantages
- Requires a high scope ratio (large loss of holding power on short scope)
- Breaks out easily if strain changes to a different angle than when set
- More prone to fouling when compared to other anchors

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Selecting an Anchor

Types of Anchors

Bruce anchor

Relatively new style anchor that has excellent holding power in sand and mud, and can be deployed on a relatively short scope.

Advantages
- No moving parts and exceptionally strong
- Requires a low force to break out from bottom
- Safe on a short scope
- No moving parts
- Will not foul its rode

Disadvantages
- Difficult to stow on deck
- Expensive

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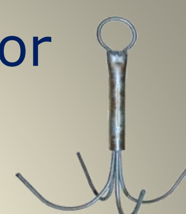
Selecting an Anchor

Types of Anchors



Reef anchor

Practical anchor for reef use. Manufactured using pipe and round bars bent to form light weight “flukes” In the case of a fouled anchor on a reef, it is hopped that the round bar “flukes” will straighten to allow the recovery of the anchor.

Advantages
- Lightweight and inexpensive to manufacture
- Holds well to reef bottom

Disadvantages
- Easy to foul on reef
- Not suitable as a general purpose anchor

Note: A vessel should never be left unattended with a reef anchor in use. At night, seek alternative anchorage where a conventional anchor can be deployed.

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Selecting an Anchor

Types of Anchors

Sea anchor

A Sea anchor in no way fulfils the role of a traditional anchor (that of keeping a vessel fixed to a selected point on the sea bed) but does have an important role to play.
In short, a sea anchors function is to provide a point of hold and resistance in the water for a vessel when it is not possible to fix ground using a traditional anchor.
A sea anchor resembles a windsock, and when deployed the bag fills with water and helps retard a vessels drift and hold her head in the required direction to the wind.

Main Purpose

- To slow down our drift
  - Also to hold the bow into the waves

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Selecting an Anchor

Types of Anchors

Sea anchor

To deploy our sea anchor, consider the following.

- If broken down – deploy from the bow
- To slow our drift – deploy from the stern

The length of line for a sea anchor should ensure that the vessel and the sea anchor are not on the wave crest at the same time. As a rule, the length of line should be half the distance between the wave crests multiplied by at least 5.
Care should be taken to ensure the multiplier is an odd number to be sure the vessel and sea anchor are not on a wave crest at the same time.

Example

Distance between wave crests is 12 meters

Therefore, 12 ÷ 2 = 6

(say use 7 {odd number} as a multiplier) 7 x 6 = 42 [so deploy 42 metres of line]

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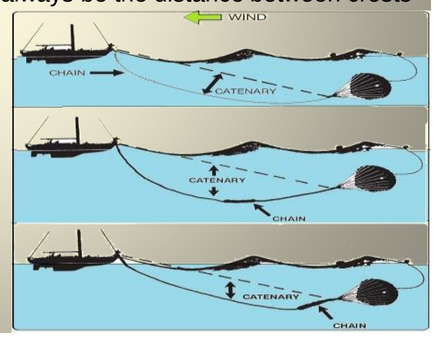
Selecting an Anchor

Types of Anchors

Sea anchor

Another rule of thumb for calculating the length of line to be used when deploying a sea anchor is to take the distance between wave crests and let out that distance plus a half distance i.e 1½ wave crests, 2½ wave crests, 3½ wave crests, 4½ wave crests etc (whatever you feel appropriate) but it must always be the distance between crests plus a half.



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Study Note

- You are working with a reef fishing charter company operating a 7.5 meter RIB vessel. The owner has asked you to purchase a new anchor for the vessel. What anchor type would be your choice?
- You are ready to leave your anchorage after an overnight stay. Your vessel is equipped with a power driven windlass. Explain the steps you would take to weigh anchor and depart.
- You are operating in an area with a mud bottom. Which anchor would you choose? Explain your choice.
- If you needed to deploy a sea anchor, explain in your own words how you would calculate the length of line let go from your vessel to the sea anchor.

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Selecting an Anchorage

Factors to consider:

- Shelter from prevailing/expected winds
- Easily accessible
- Sufficient swinging room
- Sufficient depth (all tides)
- Good holding bottom
- Location/distance of next safe anchorage
- In path of storm?
- Effect of storm surge at anchorage?
- Any submarine cables etc which make anchorage unsafe

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Anchoring Your Vessel

General Principals

- Approach into wind/tide
- Anchor on “standby” for letting go
- Confirm depth/vessel position
- Engines brought to neutral
- Slight burst astern
- Let go anchor under slight tension if possible
- Apply brake slowly
- Wait until vessel “brought up” to confirm not dragging
- Small amount of astern power to confirm anchor is holding

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Anchoring Your Vessel

Conditions to be considered before anchoring include:

- The depth of water (LAT) at the place and its approaches
- The present state of the tide and its rise and fall
- The nature of the bottom (material type and profile)
- The direction and strength of tide or current
- The direction and probable strength of the prevailing and forecast weather
- Any obstacles in the vicinity
- The swinging room available
- Being out and clear of channels and traffic
- Displaying lights and shapes

From Small Ships Training and Operational Manual Edition 6 (Qld Gov)

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Anchoring Your Vessel

Particulars to be noted on coming to anchor include:

- The depth of water
- Which anchor is to be deployed
- The length of cable
- The bearing of position
- Time of anchoring

From Small Ships Training and Operational Manual Edition 6 (Qld Gov)

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Anchoring Techniques

The steps involved in anchoring may include the following:

- Sound the area around a proposed anchorage to determine the profile of the bottom
- The depth selected must accommodate rises and falls in the tide and allow for required under keel clearances at all states of the tide
- Prepare the anchor to ensure it will run free when required (chain may be ranged or flaked on deck)
- Ensure the bitter end is secured onboard
- Plan your approach, taking into account wind and tide effects
- Veer the cable when approaching a deep anchorage to act as a submarine sentry on approaching reef or steep-to ground
- Select the position and bring the vessel dead in the water
- Ensure personnel are clear of cable

From Small Ships Training and Operational Manual Edition 6 (Qld Gov)

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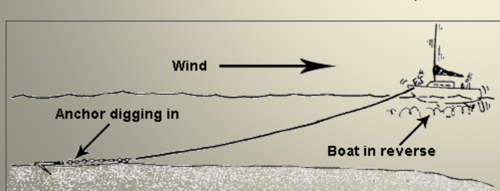
Anchoring Techniques

The steps involved in anchoring may include the following:

- Lower the anchor under control as the vessel backs (never let the rode fall on top of the anchor)
  - Side note here – Never just drop the anchor and chain over the side in a heap. It is important to pay it out slowly as the vessel backs so the chain in effect "stretches out" along the bottom. This prevents the anchor and chain twisting up, preventing the anchor from setting correctly. It should also be remembered that it is the weight of the chain that holds the vessel and that the anchors job is to prevent the chain from sliding along the bottom.
- The anchor should start to hook, or catch the bottom.



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Anchoring Techniques

The steps involved in anchoring may include the following:

- When the required scope has been let out, secure the brake and set the anchor with moderate reverse propulsion
  - Side note – We will discuss scope in greater detail shortly, but how do we determine just exactly how much chain (and therefore how much scope) we have let out?
  - On smaller vessels, the chain has painted links, usually one link every 10 meters along the chain is common. When paying out the chain, you simply count the links.
  - On larger vessels, anchor chain is supplied in 15 or 7½ fathom lengths which is then shackled together to form an anchor cable. A ship is then said to have eight or nine or whatever “shackles of cable” or “shots of cable” on each anchor. These shackles are specifically marked to identify the amount of chain let go.

From Small Ships Training and Operational Manual Edition 6 (Qld Gov)

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Anchoring Techniques

The steps involved in anchoring may include the following:

- While under reverse propulsion, check that the anchor has set by observing a transit abeam, observing the tautness of the rode and feeling the cable for vibration (if in doubt, take your time and/or start over)
- To minimise noise, take strain off the anchor windlass and provide stretch in the cable, attach a snubber (or snotter) line from the cable to a foredeck strong point.
- To relieve the windlass of strain when at anchor (also when anchor is stowed on deck) the cable is secured to a strong point using devices such as Blake Slips, or Devil’s Claws fitted with bottle screws, or chain locks and compressors. These fittings not only relieve the windlass of the tension on the cable, but also safely secures the cable to a strong point on the vessel designed to take the loading, and prevents cables slipping under strain.
- Do not stop the motor until the anchor is holding well

From Small Ships Training and Operational Manual Edition 6 (Qld Gov)

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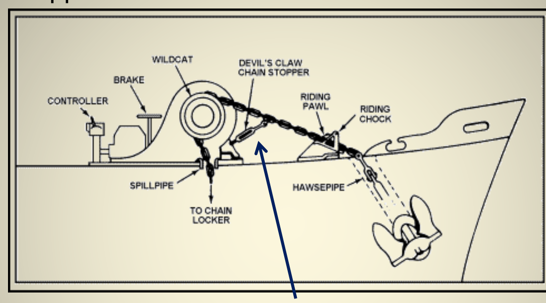
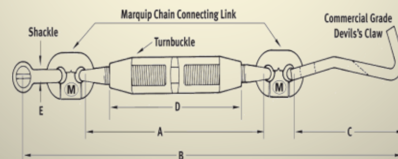
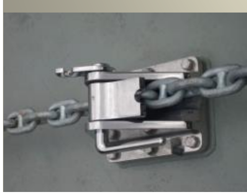
Anchoring Techniques

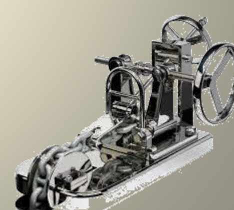
Various Chain Stoppers



Devil's Claw







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Weighing Anchor

Steps to take are:

- Start the motor and test all controls
- Motor gently along the cable as it is recovered onboard
- Wash the cable with the deck hose
- Ensure the cable does not pile up in the anchor locker (on large vessels it may need to be flaked manually)
- If the anchor is difficult to break out, secure the cable and motor gently forward
- Ensure that the anchor and cable are secured appropriate to forecast weather and sea conditions when recovered.
- A system of hand signals from the forward hand to the helm will be required for this operation to proceed smoothly

From Small Ships Training and Operational Manual Edition 6 (Qld Gov)

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Weighing Anchor

Lets go back to the second point for a moment:

- Motor gently along the cable as it is recovered onboard
  - This is an important point. The windlass is not designed to pull the vessel towards the anchor into the wind, but rather to just lift the weight of the anchor out of the bottom once the cable is straight up 90° through the water. In fact, one accepted technique to slowly "drive" the vessel over the anchor point to break the anchor free from the bottom prior to engaging the winch to haul the anchor up.

Another technique used is to take the strain on the cable with the windlass and bring up a little until the windlass just starts to work, then stop winching. The momentum of the vessel will continue forward, and when the cable has some slack, winch again until the windlass starts to work and again stop. Repeat this until your vessel is over the top of the anchor.

This technique works well if you are on your own and the winch operates from the bow only.

From Small Ships Training and Operational Manual Edition 6 (Qld Gov)

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Anchoring Your Vessel

Scope and Scope Ratios

It should be remembered that the anchor line itself is a major component in the anchoring system.

Sufficient scope (the ratio of the length of the line to the depth of the water) helps to keep the anchor from dragging. A long rode (the anchor line between the vessel and the anchor) tends to exert a horizontal pull and helps the anchor dig in. For best performance, the line should lead away from the anchor at an angle of not more than 80° to the bottom.

Factors to consider when deciding scope
- Nature of the bottom
- Windage of the vessel
- The anticipated winds
- The type of anchor
- The nature and length of stay
- The type and size of the anchor rode

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Anchoring Your Vessel

Scope and Scope Ratios

As a general guide, five to one (length of cable five times the depth of water) can be taken as acceptable in most situations.

More specifically, in water 6 to 9 meters deep, use a seven to one ratio.
In deeper water, less scope may be used given the catenary effect of the system.

There are of course many variables that will affect your decision when determining scope, some of those mentioned earlier. Use the following as a general guide.

Scope Ratios

▪ For Chain	3:1	Minimum
	5:1	Better
	7:1	Heavier weather
▪ For Rope	7:1	Minimum
	10:1	Heavier weather

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Anchoring Your Vessel

Scope and Scope Ratios

RECOMMENDED SCOPE

Sea Conditions	Anchor Cable Type	Scope
Favourable	Chain	3:1
Average	Chain	5:1
Rough	Chain	7:1
Favourable	Rope ***(plus chain pennant)***	5:1
Average	Rope	8:1
Rough	Rope	10:1

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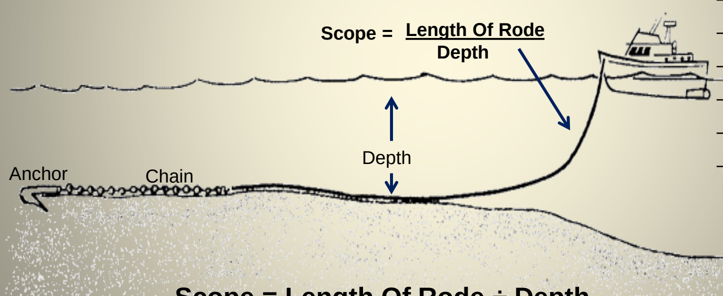
Anchoring Your Vessel

Scope and Scope Ratios



Scope	Holding Power
10:1	100%
7:1	91%
6:1	85%
5:1	77%
4:1	67%
3:1	53%
2:1	35%

Scope = Length Of Rode ÷ Depth

Or

Length of Rode ÷ Depth = Scope

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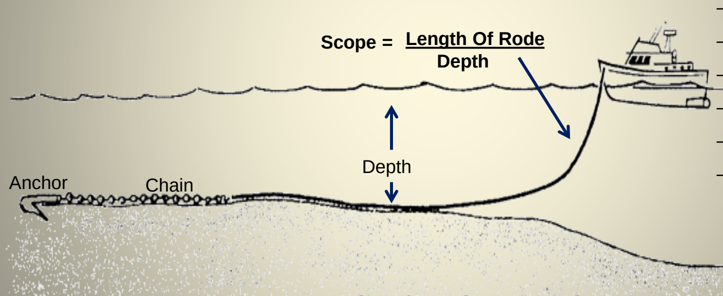
Anchoring Your Vessel

Scope and Scope Ratios

Example **Our water depth is 18 meters, length of rode is 140 meters**



Scope	Holding Power
10:1	100%
7:1	91%
6:1	85%
5:1	77%
4:1	67%
3:1	53%
2:1	35%

Scope = Length Of Rode ÷ Depth
Scope = 140 ÷ 18
Scope = 7:1 **(always round down)**

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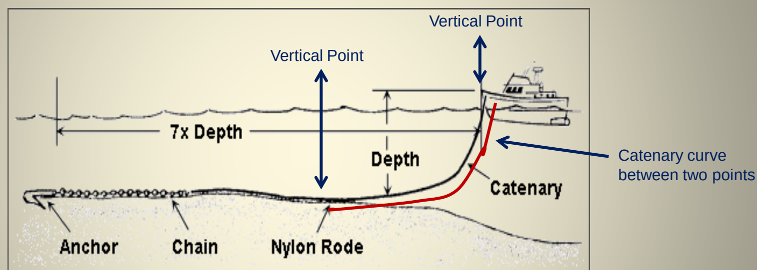
Anchoring Your Vessel

Catenary

The curve formed by a uniform chain hanging freely from two points not in one vertical line.



The most important thing about scope is how it acts in a blow when wind and seas build up a strain on the rode. Under these conditions, the catenary (sagging curve) in the line cushions the load on the anchor and absorbs shocks that would be transmitted directly to the ground tackle if there were a straight line pull on the rode.

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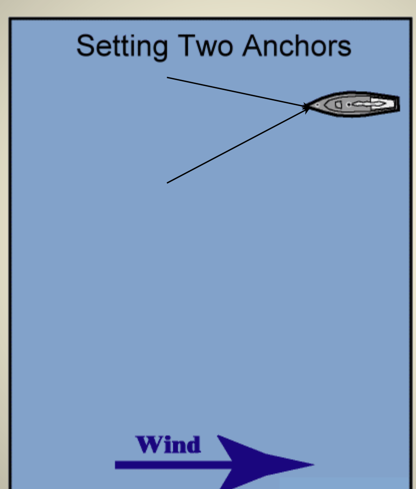
Anchoring



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Class Discussion

- We have previously discussed that a windlass is not designed to haul a vessel into the wind and winch the vessel to the anchor point. With that in mind, how would you work through the following situation?

- You are alone onboard a 20 meter fishing vessel and have been at anchor overnight. You are preparing to leave the anchorage in the morning, your anchor has an 8:1 scope out, you have a power windlass which can only be operated from the bow. You also estimate a 12 knot wind is pushing the vessel back from the anchor point.

How would you recover the anchor without putting undue stress on the windlass?

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Thankyou

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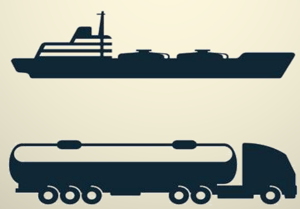
REFUELLING



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Refuelling

On completing this session

You will

- ✓ Be able to describe the planning process to safely refuel a vessel, including steps to be taken prior to, during and following refuelling.
- ✓ Understand the general precautions to follow to safely refuel a vessel.
- ✓ Be able to explain common refuelling problems that can lead to an emergency.
- ✓ Be able to detail the steps to resolve refuelling emergencies.
- ✓ Explain how to deal with a fuel spill and potential pollution issues.
- ✓ Review aspects of WHS/OHS with regard to stowing and using dangerous goods.
- ✓ Be able to carry out fuel consumption calculations

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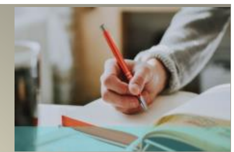
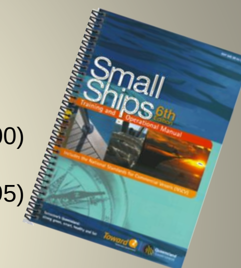
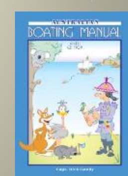


Refuelling

Recommended Study Reference



Small Ships Training and Operational Manual – Edition 6
Maritime Safety Queensland
Chapter 6 – Refuelling precautions (pg 100)
Chapter 15 – Fuel calculations (pg 243)
Chapter 18 – Fire risks & refuelling (pg 295)



Australian Boating Manual
Capt. Dick Gandy
Chapter 5 – Dangerous materials (pg 113)
Chapter 12 – Refuelling a vessel (pg 304)
Chapter 19.4 – WHS & work practices (pg 676)

Online Resources
Refuelling - https://www.boatsafetyscheme.org/stay-safe/petrol-safety/refuelling/

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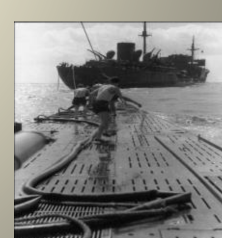
Refuelling Planning

Prior to Refuelling

A very important part of any vessel refuelling operation, including the planning, preparation, precautions and dealing with any emergencies, is to consult the vessels SMS which should contain the vessel's refuelling procedure.

The refuelling procedure could include any of the following items as shown under the following broad headings of;

- Refuelling planning (prior, during and following)
- Refuelling precautions
- Refuelling emergencies
- May include information regarding fuel consumption and calculations



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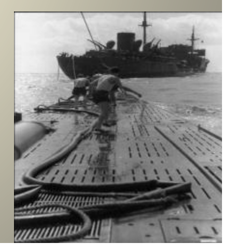
Refuelling Planning

Prior to Refuelling

- Get out and follow procedure from vessel SMS and use the refuelling check list to document compliance.
- Dip all fuel tanks to establish the current amount of fuel already on board.
- Calculate the amount of fuel required to bring tanks to required levels
- Order required grade and amount of fuel following company procedures



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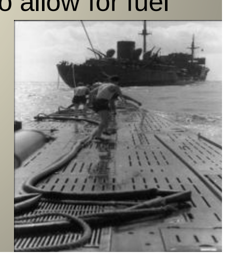
Refuelling Planning

Prior to Refuelling

- If required, consult with port authority to arrange an agreeable time and place if refuelling ship to ship, or suitable wharf and time if bunkering tanker to ship, allowing for expected time frames from start to finish.
- Make up Ullage report on all tanks in preparation for refuelling as this can save considerable time and paperwork.
- Remember when calculating Ullage and fuel volume to be bunkered that any tank can only be filled to 95% of its capacity to allow for fuel expansion.



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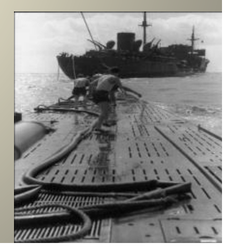
Refuelling Planning

Prior to Refuelling

- Calculate the impact of the refuelling operation on vessel safety and the effect on the vessels stability
- Establish communications with shore staff and set up exclusion zone
- Inform port authority or VTS of fuel transfer operations before commencing.
- Check condition of all hoses, connectors and test date of hoses
- Check and have ready all additional items such as spill kit and PPE

PPE could include

- Gloves (riggers or rubber for example)
- Eye protection
- Suitable footwear
- Protective clothing (coveralls)



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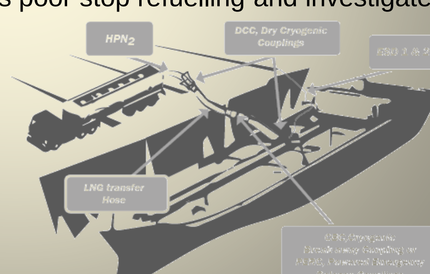
Refuelling Planning

During Refuelling

- Secure fuel hoses and lock wire connections on large hoses to prevent hoses becoming uncoupled
- Keep fuel nozzle in contact with filler pipe on small hoses
- Select valves to direct fuel to correct tank and when flow starts check breathers to ensure fuel is going to correct tank
- Take fuel samples during filling process, label and stow as part of fuel quality monitoring. If quality looks poor stop refuelling and investigate.



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Refuelling Planning

Following Refuelling

- Cap off and remove hoses from vessel or if using vessels hoses stow them away.
- Obtain bunker receipt for records
- Obtain fuel Sulphur report and analysis for records
- Enter refuelling amount in ships log
- Make up oil record book
- Close off refuelling check lists and file away
- Ventilate vessel before start up

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Refuelling Precautions

Refuelling can be a hazardous time for fire risk and precautions should always be taken to manage this risk.

Hydrogen gas from batteries, and fuel vapours are leading elements in boating accidents involving fires and explosions, with fuel being the most common, particularly so when refuelling.

To put the very real dangers of explosion into perspective, consider this: one cupful of vaporised petrol in a small space such as an engine compartment, has the explosive power of 15 sticks of dynamite!

A fire needs three elements to keep burning – fuel, heat and oxygen. If you remove any one or more of them, it will go out. Simply put, with a fuel fire – if possible – you should turn off the gas or petrol/diesel supply and/or remove combustible material. Heat can be counteracted by applying cold water and, perhaps most importantly, you can smother fire by cutting off the oxygen with an extinguisher using CO_2, dry powder or foam.

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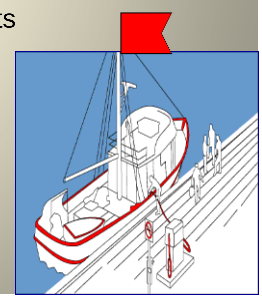
Refuelling Precautions

Refuelling can be a hazardous time for fire risk and precautions should always be taken to manage this risk. **(remember to consult SMS and refuelling procedures)**

Appropriate measures may include:

- Moor vessel securely but with ability to let go quickly
- Move passengers ashore
- Hoist Bravo flag (code B)
- Ensure motors off, vents are closed, intake fans turned off
- Shut down machinery and close any electrical circuits
- Close gas valves, no naked lights and no hot work
- No smoking signs out
- Maintain watch for smoking/naked flames
- Avoid radio and mobile phone use
- Earth deck-fill plate to tank



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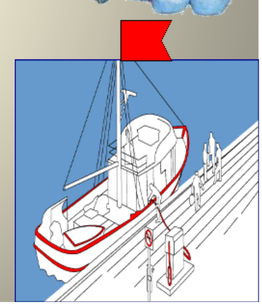
Refuelling Precautions

Refuelling can be a hazardous time for fire risk and precautions should always be taken to manage this risk.

Appropriate measures may include:

- Have fire extinguishers ready on deck
- Remove portable tanks from vessel to fill
- Block deck scuppers and put containers under tank vents
- Have spill kit close at hand
- Ground hose nozzle during filling to provide earth connection
- Sound tanks and record Ullage
- Maintain constant watch on fuel flow and monitor fill rate and tank level



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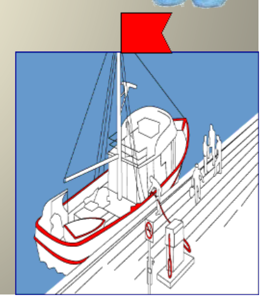
Refuelling Precautions

Refuelling can be a hazardous time for fire risk and precautions should always be taken to manage this risk.

Appropriate measures may include:

- Consider stability when filling wing tanks
- Slow fill rate as tanks approach max fill level
- Ventilate risk areas after filling
- Check bilges after refuelling
- On completion of fuel bunkering drain hoses before disconnecting by walking the fuel out or blowing the hoses through



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Refuelling Emergencies

- Broken mooring lines allowing vessel to swing out. Stop flow and re-secure vessel, check all hose connections before recommencing bunkering
- Hose leaks, stop the flow and fix or replace hose.
- Fire and explosions, raise the alarm and stop the flow, check for casualties, inform authorities, fire control, remove hoses from deck if possible, prepare to abandon ship if you lose control, possibility of fire spreading from ship, radio for assistance urgently.

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Refuelling Emergencies

- If transfer pressure to high, ask for reduction in flow rate and pressure.
- Fuel going to wrong tanks, open valve to correct tank and then close off wrong tank. Never close of valves from delivery manifold as supply hose may burst and always consult bunker control staff before closing any valves.
- If in any doubt, stop the flow immediately.
- You must complete an incident report for any fire/explosion, complete a POLREP for any spill, and enter details in ships log.

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Refuelling Emergencies

Group discussion

We are working on our vessel and have just had a fuel spill whilst filling our tanks. What actions do we take to deal with the spill?

- Stop refuelling and stop the flow of fuel into the water
- Inform crew and vessels in the immediate vicinity that a spill has occurred and a fire hazard may exist
- Contain the spill as much as possible, and minimise the effect and spread of the spillage (use booms, absorbent pads and materials)
- Take fire precautions
- Consult vessel SMS procedures for details on dealing with a spill
- If vessel over 35mtrs consult SOPEP {shipboard oil pollution emergency plan}
- Advise vessel owner/operator or responsible person {as designated in SMS}
- Conduct on board clean up
- Advise the relevant authorities {MSQ, AMSA, relevant state body} POLREP
- Don't use oil dispersants in water unless advised by the local authority
- Logging incident in vessel log book

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Stowing Flammable Goods

Many products, such as petrol, are dangerous by themselves. There are other products that become dangerous or more dangerous when combined with other products.

Most vessels would have some of these products on board for their own use, items such as petrol for outboards, bleach for cleaning, paints and paint thinners, for example.

By law, manufacturers and/or suppliers of hazardous products must provide a Safety Data Sheet (SDS) when supplying these goods.

Every SDS gives the user the product safety information, including the components of the product, any hazards or dangers in using the product, and advice on handling and storing products.

Problems can arise when paints and cleaning agents are stored in inaccessible places on board. They may be in incompatible with one another, be out of sight, containers may start to leak or rust.

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Stowing Flammable Goods

WHS/OHS Regulations pertaining to stowage and SDS in the workplace

- Manufacturers are required to classify chemicals and prepare SDS's
- Employers must ensure that labels are applied to containers and that SDS are made accessible to workers who may be exposed to the chemicals
- You should also ensure that all chemicals and dangerous goods have appropriate labels on the packaging
- All hazardous substances and dangerous goods used in the workplace must be listed on a register (usually referred to as the "Chemical Register") together with the relevant SDS
- You must have on board a SDS for every chemical and dangerous good used and carried on the vessel
- Employees must have access to the register ("Chemical Register")
- Complete risk assessment's and/or JSA prior to using or storing dangerous goods and follow advice contained in the SDS

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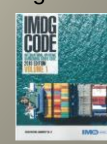
Storing Chemicals & Dangerous Goods

If you are carrying dangerous goods as cargo

- You must follow the stowage regulations and precautions as laid down in the International Maritime Dangerous Goods Code (IMDG Code)
- You must have a pre-stowage plan for dangerous goods showing the proposed location of stowage.
- You must have a final-stowage plan for dangerous goods showing the exact location of stowage.
- Complete form MO 41/3 advising local authorities of intention to ship dangerous goods.
- Complete a dangerous goods manifest.
- You must have a risk assessment completed for the carriage of dangerous goods



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Study Note

- ➢ You should be able to list a number of items you would find in a spill kit. Be able to list at least six items.

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Fuel Calculations

If a vessel travels at 9 knots with a single motor burning 105 litres per hour, how much fuel is required to travel 360 nm before allowing for reserves?

First we need to find how long we will be steaming for to cover the 360 Nautical Miles. So 360NM divided by the speed we are traveling at 9 knots gives the hours to complete the trip = 40 hours.

Now we multiply the 40 hours we are steaming by the fuel we burn every hour to give us the fuel we will require for the trip. So 40 hours times the 105 litres burnt every hour gives us the fuel used for the trip
40 x 105 = 4200 litres for the trip

Distance divided by speed in NM per hour = time to complete the trip

Time to complete the trip multiplied by the fuel burnt each hour = the fuel required for the trip

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Fuel Calculations

If a vessel travels at 6 knots with a single motor burning 12 litres per hour, how much fuel is required to travel 360 nm before allowing for reserves?

360 N Miles divided by the 6 knots gives the hours to complete the trip = 60 hours. 60 hours times the 12 litres gives the fuel used = 720 litres for the trip

How far can a vessel travel with 1000 litres of fuel aboard with a single motor burning 19 litres an hour at 20 knots?

1000 litres divided by 19 litres gives the hours the fuel will last = 52.63 hours
52.63 Hours times 20 knots per hour = 1052.63 N Miles travelled on the 1000 litres

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Thankyou

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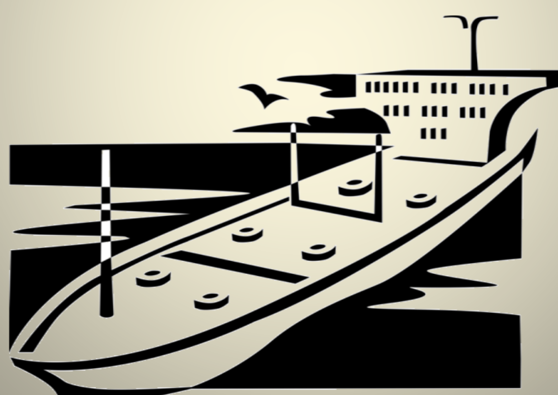
ECA Maritime COLLEGE

STABILITY



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SHIP STABILITY

SYLLABUS

- Stability
- Buoyancy
- Displacement
- Reserve Buoyancy
- List
- Trim
- Angle of Loll
- Simplified Stability Data
- GZ Curve

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Stability

On completing this session

You will

- ✓ Explain the meaning of common stability terminology.
- ✓ Have an understanding of Archimedes Principle.
- ✓ Describe how weight and buoyancy combine to assist floatation.
- ✓ Understand the effects of Transverse and Longitudinal stability.
- ✓ Be able to identify three types of vessel equilibrium.
- ✓ Explain the difference between "stiff" and "tender" vessels, and the difference between List and Loll.
- ✓ Explain what "free surface effect" is.
- ✓ Be able to identify various stability problems and dangers.
- ✓ Be able to calculate various vessel stability conditions.

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Stability

Common Terms used in this session

You should take time to study the following terminology and to understand the meaning of each. At the end of this session you should be able to describe each in your own words.

Centre of Gravity (G) The centre of mass, the point from which the whole weight of a body (such as a vessel) and everything in it acts vertically downward

Vertical Centre of Gravity (VCG) Centre of the weight distribution in a vessel and the point through which the force of gravity is assumed to act vertically downward

Centre of Buoyancy (B) The centre of gravity of the immersed volume. Point through which the force of buoyancy supporting the vessel acts vertically upwards

Vertical Centre of Buoyancy (VCB) Centre of the underwater volume and the point through which the forces of buoyancy act vertically upward

KG Reference to height - Line of the Keel (K) to the Centre of Gravity (G)

KB Reference to height - Line of the Keel (K) to the Centre of Buoyancy (B)

KMT Reference to height - Line of the Keel (K) to Traverse Metacentre (MT)

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Stability

Common Terms used in this session

Longitudinal Centre of Gravity (LCG) Longitudinal position of Gravity (G)

Longitudinal Centre of Buoyancy (LCB) Longitudinal position of Buoyancy (B) {often aft of amidships}

GZ Lever The horizontal distance (in the transverse plane) between a vertical line drawn upwards through the centre of buoyancy, and a vertical line drawn downwards through the centre of gravity

Metacentre (M) Point of the centreline of a vessel that remains vertically above the centre of buoyancy when a vessel heels (a fixed point for small angles of heel)

Metacentric Height (GM) Vertical distance between the centre of gravity and the metacentre

Heel Movement of a vessel away from upright by an external force (wind, waves, high speed turning etc)

Displacement Total weight of the water displaced by a floating vessel (equal to the weight of the vessel, including cargo)

Light Ship {lightship displacement} The weight of the hull, all machinery and spare parts, excluding deadweight

Dead-Weight The difference between light and loaded displacements (that is, weight of items such as fuel, water, stores and cargo, added to lightship

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Stability

Common Terms used in this session

Loaded Displacement The weight of the vessel when loaded and of the water displaced

Synchronous Rolling A state in which the period of roll of a vessel coincides with the period of its encounter with waves (causes excessive rolling)

Reserve Buoyancy The watertight volume of a vessel above the waterline

Freeboard The vertical distance from the lowest point of the main deck (usually near midships) to the waterline

Draft The depth of the vessel below the waterline; the amount of vertical distance from a vessels water line to the bottom of it's keel

Fresh Water Allowance (FWA) Amount by which the draft changes when a vessel moves between salt and fresh water

Tonnes per Centimeter (TPC) Tonnes of displacement required to change the vessels draught by one centimetre

Positive Stability Stable Equilibrium {positive GM} Centre of Gravity (G) is below the Metacentre (M)

Negative Stability Unstable Equilibrium {negative GM} Centre of Gravity (G) is above the Metacentre (M)

Neutral Stability Neutral Equilibrium {zero GM} Centre of Gravity (G) and the Metacentre (M) coincide. Note - this condition is regarded same as negative stability

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Stability

Common Terms used in this session

Loll The condition when the forces of buoyancy and gravity align and establish positive stability at an angle of lean, despite the vessel having a negative GM when it is in the upright position

List Movement of a vessel away from upright because of uneven transverse distribution of weight e.g. a weight on one side – G off centre line (damage for example)

Trim Difference between the forward and aft draughts

Righting Moment A rotational force generated by the length of the GZ lever and the vessels displacement that will return the vessel upright

Stiff Vessel A vessel with a low centre of gravity such that it returns upright very quickly when heeled

Tender Vessel A vessel with a high centre of gravity such that it returns upright very slowly when heeled

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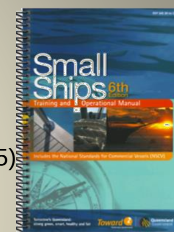
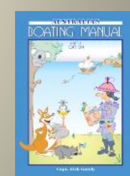
Stability

Recommended Study Reference

Small Ships Training and Operational Manual – Edition 6
Maritime Safety Queensland
Chapter 19 – Maintaining Stability (pg 303)
Chapter 20 – Condition & Seaworthiness(pg 315)
Chapter 25 – Other Stability Factors (pg 380)



Australian Boating Manual
Capt. Dick Gandy
Chapter 1 – Stability Definition (pg 14)
Chapter 13 – Load, Buoyancy & Stability (pg 323)



Online Resources
Stability - https://en.wikipedia.org/wiki/Ship_stability

https://www.marineinsight.com/?s=stability

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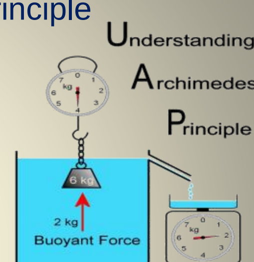
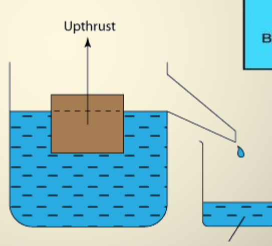
Stability

Understanding Archimedes Principle



"A body wholly or partially immersed in a fluid loses weight equal in amount to the weight of the fluid it displaces"



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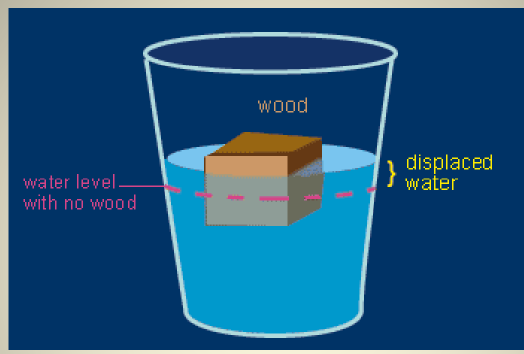
Understanding Archimedes Principle



When you place a block of wood into a bucket of water, the block displaces some of the water, and the water level goes up.

If you could weigh the water that the wood displaces, the displaced water would equal the weight of the wood.

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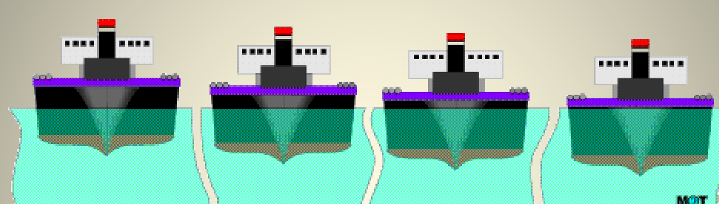
Understanding Archimedes Principle



Why does a boat float?

- It displaces an amount of water equal to its own weight
- The boat will sink lower in the water until the displaced weight of water equals the weight of the boat
- If the boat is heavier than the amount of water displaced by the hull, the boat will sink

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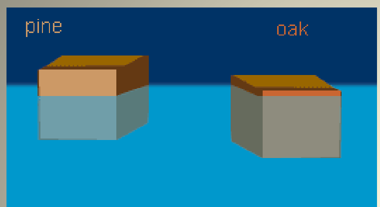
Understanding Archimedes Principle



ball: displaced water weighs less than ball
hull: displaced water weight = hull weight

If you placed 2 blocks of different density into water, they would float at different levels because one is heavier than the other, and displaces more water.

Remember, an object displaces its own weight of the water in which it is immersed.

If the area of the object is shaped in the form of a boat, the object would sink down to the point where its own weight of water was displaced

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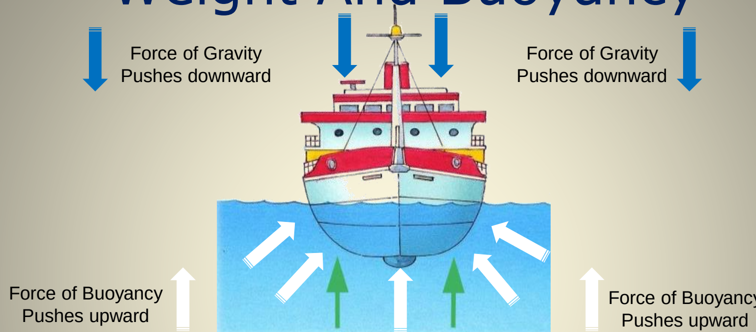
Weight And Buoyancy



- Force of Gravity (weight of vessel) acts downwards
- Force of Buoyancy (equal to weight of displaced fluid) acts upwards
- When force of Buoyancy is greater than force of Gravity, vessel floats
- When force of Gravity is greater than force of Buoyancy, vessel sinks

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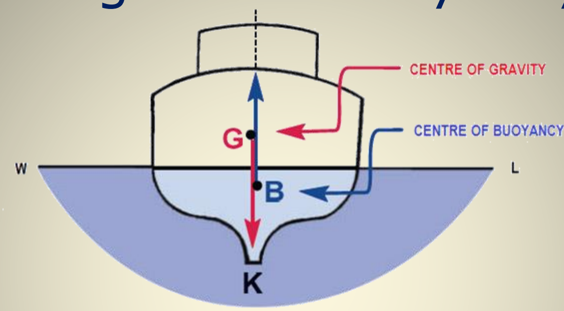
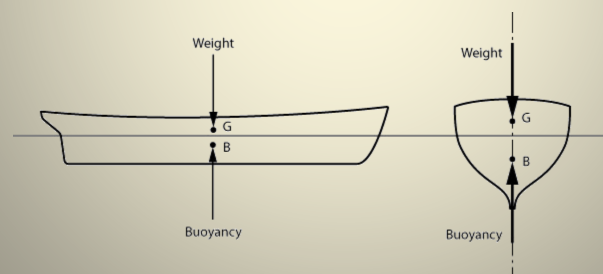
Weight And Buoyancy





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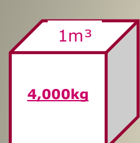
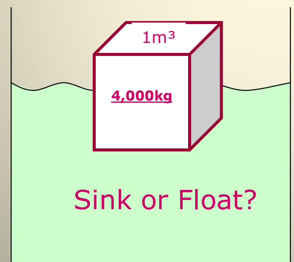
Weight And Buoyancy

Example 1



Place in fresh water



Note:
1 cubic metre of Fresh Water weighs 1,000 kg (1 tonne)

An object displaces its own weight in water

For the object to float, its own weight must be less than the weight of water displaced

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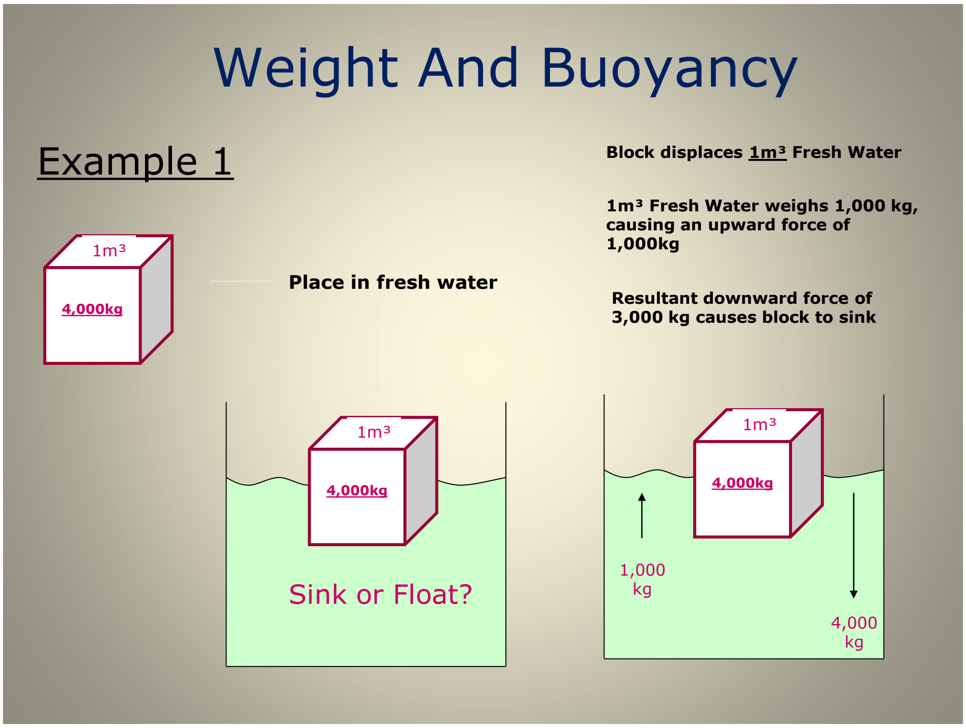
Weight And Buoyancy
Example 1
1m³
4,000kg
Place in fresh water
Sink or Float?
Block displaces 1m³ Fresh Water
1m³ Fresh Water weighs 1,000 kg, causing an upward force of 1,000kg
Resultant downward force of 3,000 kg causes block to sink
1,000 kg
4,000 kg

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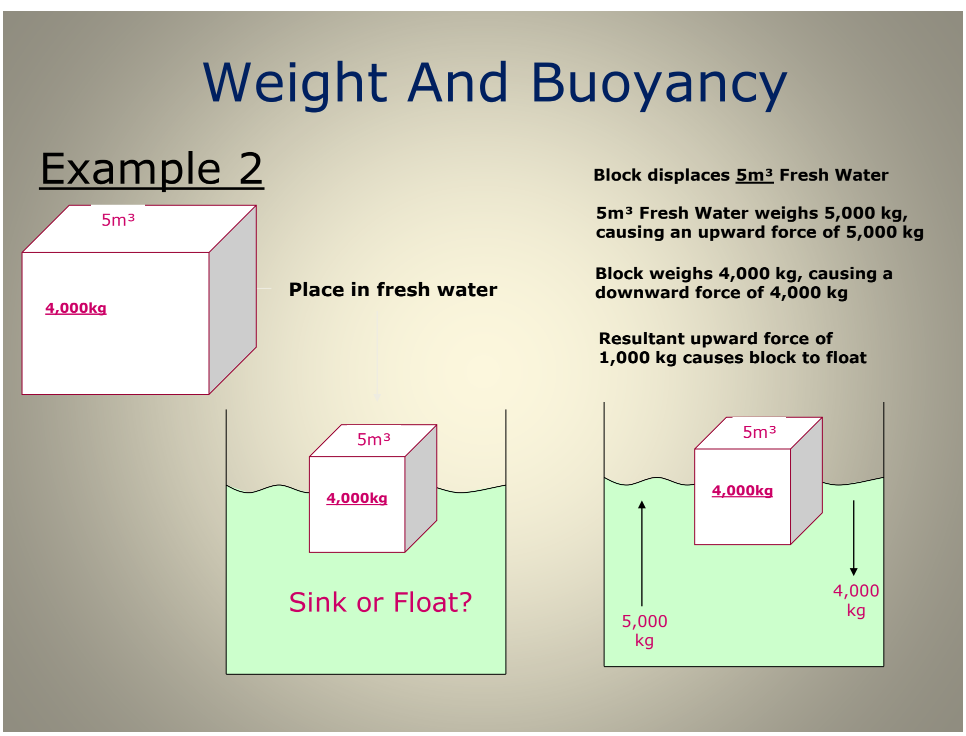
Weight And Buoyancy
Example 2
5m³
4,000kg
Place in fresh water
Sink or Float?
Block displaces 5m³ Fresh Water
5m³ Fresh Water weighs 5,000 kg, causing an upward force of 5,000 kg
Block weighs 4,000 kg, causing a downward force of 4,000 kg
Resultant upward force of 1,000 kg causes block to float
5,000 kg
4,000 kg

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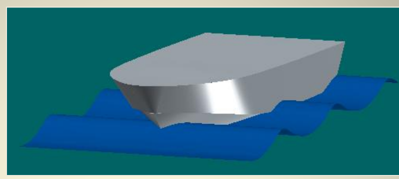
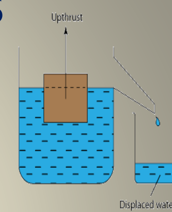
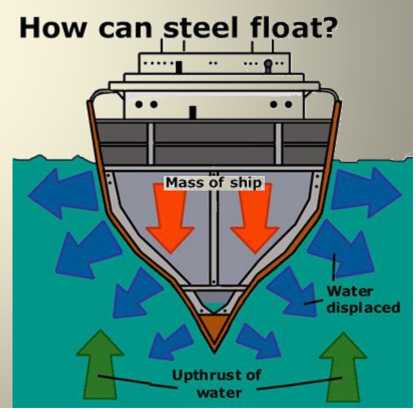
Terms And Definitions

Displacement





- A floating vessel displaces its own weight in water
- i.e. the portion of hull below water displaces a weight of water equal to the weight of the vessel



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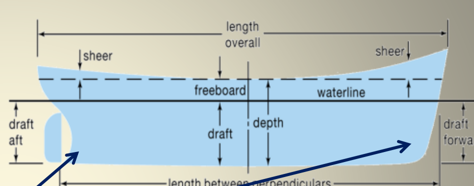
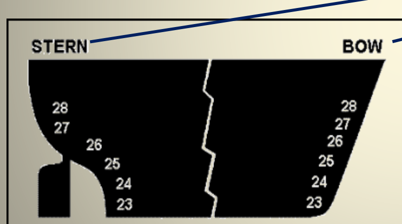
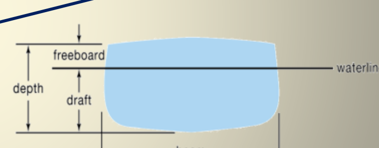
Terms And Definitions

Draft

- Distance from underside (lowest part) of hull to water surface







- Numbers indicate Draft Forward and Aft

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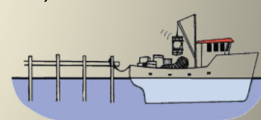
Terms And Definitions

- Light Displacement

No weights on board *(only hull, superstructure, accommodation, machinery)*

- Load Displacement

Fully loaded *– fuel, fresh water, cargo, gear, crew etc.*



- Deadweight

Difference between "Load Displacement" and "Light Displacement"

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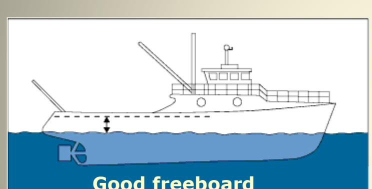
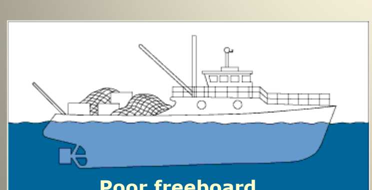
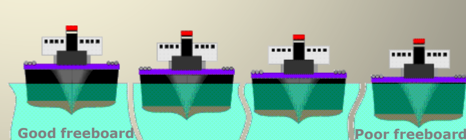
Terms And Definitions

Freeboard

"Distance from the waterline to the deck"







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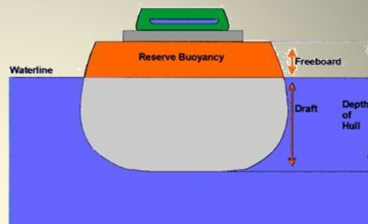
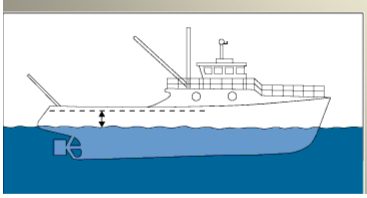
Terms And Definitions

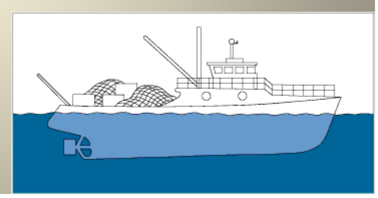
Reserve Buoyancy



Amount of Freeboard is a measure of the amount of buoyancy which is left above the water line to support the vessel in case of bad weather or damage

When Reserve Buoyancy is gone, vessel sinks!





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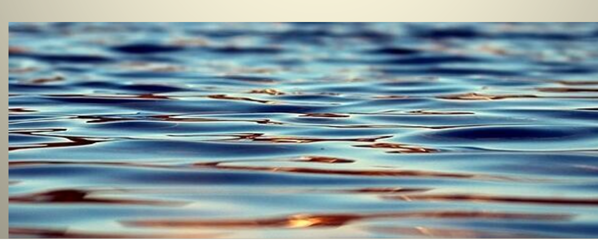
Terms And Definitions

Density

Relationship between Weight and Volume = DENSITY

- One cubic metre of fresh water weighs 1 tonne
  Density of fresh water = 1.000 tonne/m³
- One cubic metre of Salt Water weighs 1.025 tonnes
  Salt water has a density of 1.025 tonnes/m³



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Terms And Definitions

Relative Density (Specific Gravity)

- RD = “Ratio of the weight of a substance to the weight of an equal volume of fresh water”
- RD = $\frac{\text{Density of Substance}}{\text{Density of Fresh Water}}$

e.g., Relative Density of sea water = $\frac{1.025}{1}$

= **1.025**

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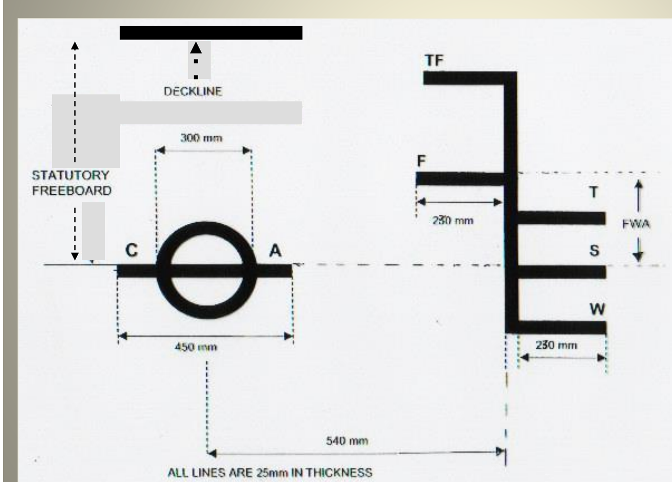
Terms And Definitions

Loadlines

– indicate the draft to which a vessel can be loaded



TF - ***Tropical Fresh Water***

F - ***Fresh Water***

T - ***Tropical Sea Water***

S - ***Summer, Sea Water***

W - ***Winter, Sea Water***

CA – These letters indicate the registration society, in this case Commonwealth of Australia

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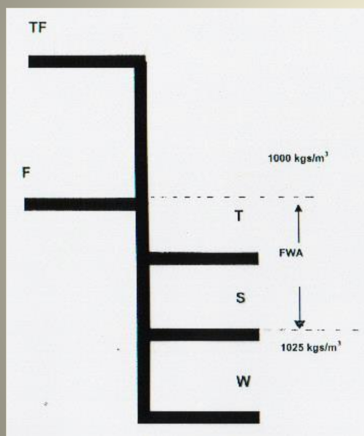
Terms And Definitions

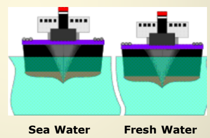
Fresh Water Allowance

In Sea Water, will a vessel float higher or lower than in Fresh Water?



1 Cubic Metre of Fresh Water weighs 1 Tonne
(1 Cubic Metre of Fresh Water will balance 1 Tonne of weight)

1 Cubic Metre Sea Water weighs 1.025 Tonnes
(1 Cubic Metre of Sea Water will balance 1.025 Tonnes of weight)



The draft of a vessel in Sea Water will be less than the draft in Fresh Water

A vessel loading in a river will be allowed to load to the Fresh (F) line, given that in Sea Water the vessel will rise to the Summer (S) load line

Difference between top of Summer (S) line and top of Fresh (F) line is the FRESH WATER ALLOWANCE

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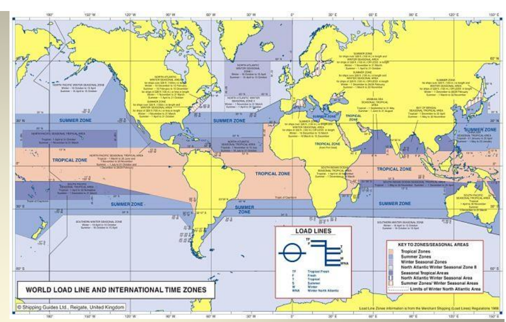

- Load Line Regulations Chart ☐ (indicates world zones for vessel loading purposes)
- Seasonal zones are dated and loosely related to the seasons of the year
- The Tropical, Summer, and Winter marks must not be submerged when the vessel is trading in a designated Tropic, Summer or Winter Zone

(Exaggerated example)

- Measurements are made to the tops of the lines

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Stability

The T.P.C. for any draft is the weight in TONNES required to submerge or raise the vessel 1 cm in draft

The value of T.P.C. for any vessel is given for every draft reading in her Stability Book under Hydrostatic Details

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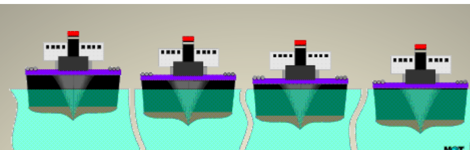

NEVER SUBMERGE YOUR LOADLINE

(i.e., DO NOT OVERLOAD YOUR VESSEL)

You must know:

- **DRAFT,** which will give you your vessel's DISPLACEMENT (from the Displacement table in your Stability Book)
- **T.P.C. (Tonnes Per Centimetre) -** the amount by which the draft will change (increase or decrease) when weights are added or discharged
- *The allowances to be made when you are loading in water other than salt, in the Summer Zone - Remember, the density will change, and thus the vessels draft will change as she proceeds from one Zone or Density, into another.*

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Example:
(from Stability Book)

HYDROSTATIC DRAFT (m)	DISPLACEMENT (tonnes)	TPC	MCT 1cm (t - m)	LCF (m aft 0)	KM (m)
2.00	87.5	0.980	0.885	- 0.295	4.47
2.05	93.5	1.000	0.945	- 0.380	4.41
2.10	101.0	1.022	1.000	- 0.465	4.35
2.15	105.5	1.040	1.060	- 0.555	4.29
2.20	111.2	1.062	1.115	- 0.650	4.24
2.25	116.8	1.078	1.172	- 0.750	4.20
2.30	122.0	1.098	1.235	- 0.860	4.15
2.35	127.5	1.115	1.292	- 0.955	4.11
2.40	133.2	1.128	1.340	- 1.010	4.07
2.45	139.0	1.140	1.390	- 1.045	4.03
2.50	145.0	1.150	1.145	- 1.065	4.00
2.55	150.5	1.160	1.430	- 1.070	3.97
2.60	156.5	1.168	1.438	- 1.072	3.94
2.65	162.5	1.172	1.465	- 1.065	3.91
2.70	168.0	1.180	1.490	- 1.060	3.89
2.75	174.0	1.185	1.500	- 1.050	3.87
2.80	180.0	1.190	1.515	- 1.042	3.85
2.85	186.0	1.195	1.532	- 2.038	3.84
2.90	192.0	1.200	1.550	- 1.030	3.82
2.95	198.0	1.208	1.568	1.022	3.81
3.00	204.0	1.212	1.585	- 1.015	3.81
3.05	210.0	1.218	1.605	- 1.008	3.80
3.10	216.2	1.220	1.622	- 0.995	3.80
3.15	222.2	1.225	1.640	- 0.988	3.79
3.20	228.2	1.230	1.660	- 0.978	3.79
3.25	324.5	1.240	1.670	- 0.968	3.78

Draft (salt water) = 3.00m

DISPLACEMENT = 204.0 Tonnes

T.P.C. = 1.212

KM (Keel to Metacentre) = 3.81m

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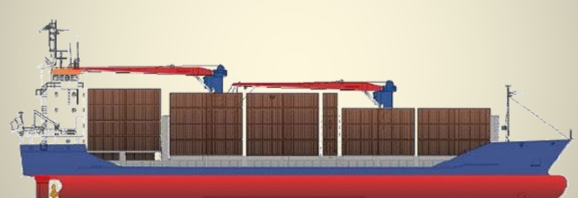
TRANSVERSE AND LONGITUDINAL STABILITY



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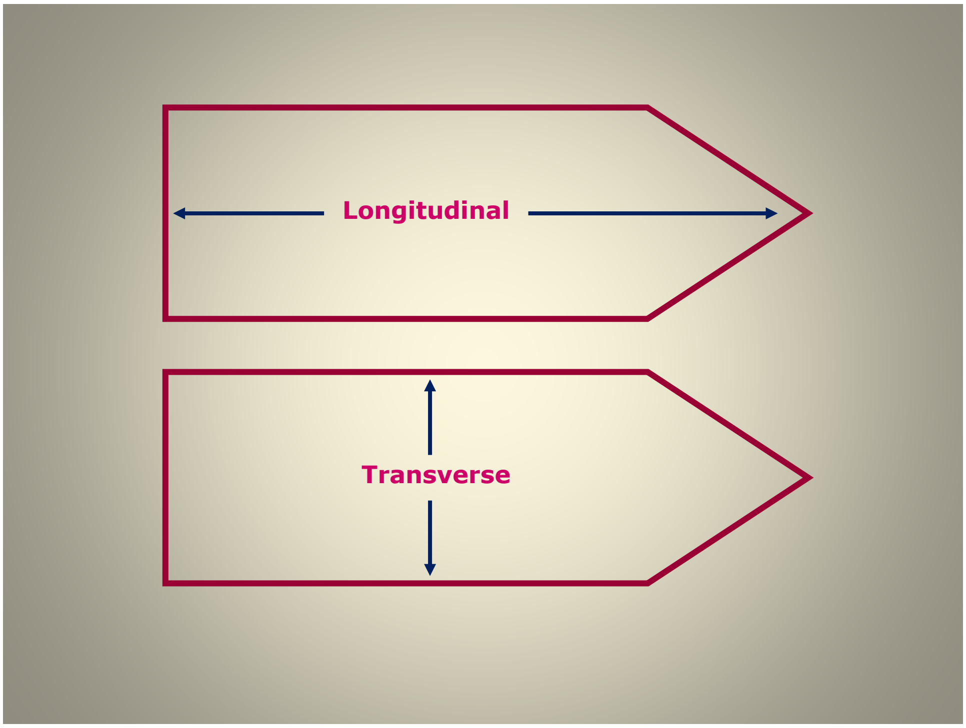
Longitudinal
Transverse

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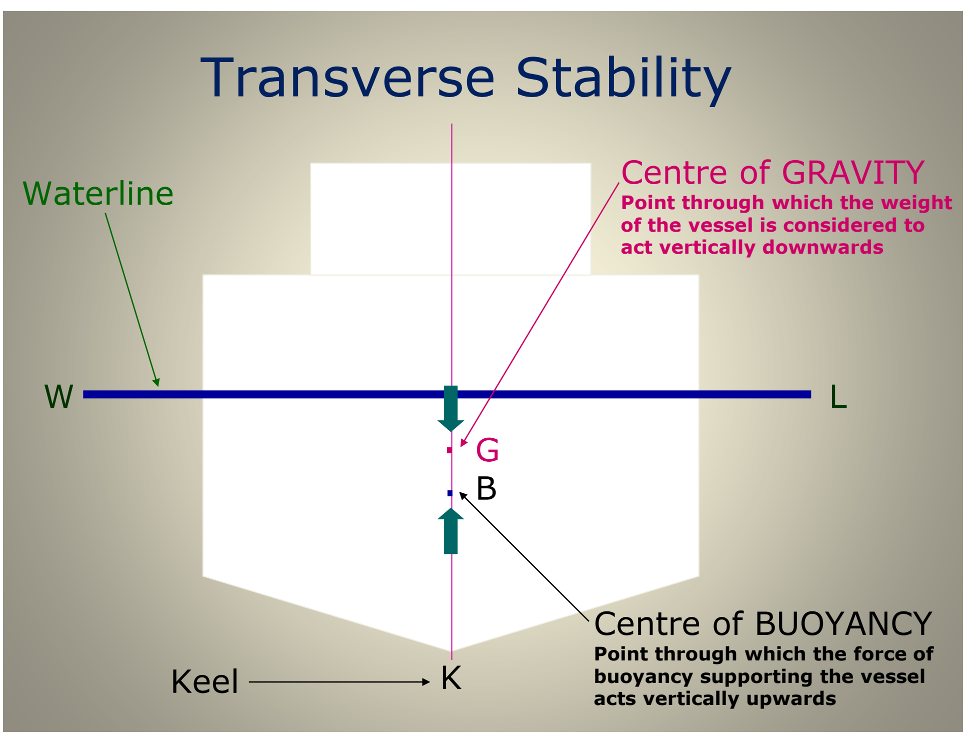
Transverse Stability
Waterline
Centre of GRAVITY
Point through which the weight of the vessel is considered to act vertically downwards
W
L
G
B
Centre of BUOYANCY
Point through which the force of buoyancy supporting the vessel acts vertically upwards
Keel
K

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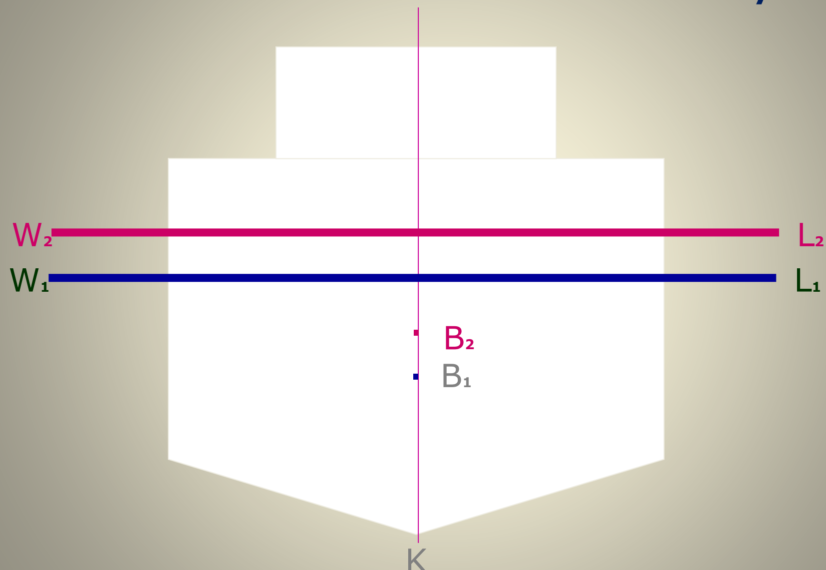
Movement Of Centre Of Buoyancy



As the vessel sinks deeper in the water, the centre of Buoyancy will rise

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Movement Of Centre Of Gravity

<u>Depends on:</u>

- **Size of weights added/discarded**
- **Position where weighs added/discarded**

<u>3 rules describe movement of vessel's Centre of Gravity when:</u>

- Weight is added
  - Centre of gravity moves <u>Towards</u> an added weight
- Weight is removed
  - Centre of gravity moves <u>Away</u> from a removed weight
- Weight is shifted
  - Centre of gravity moves <u>Parallel</u> to the movement of a weight which is already onboard

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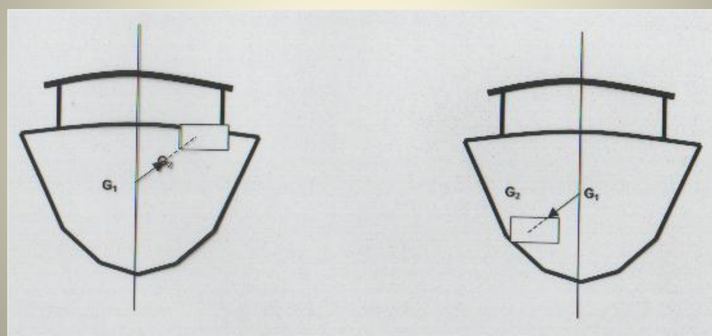
Movement Of Centre Of Gravity

Weight Added



Centre of Gravity moves <u>TOWARDS</u> an added weight (From G1 to G2)

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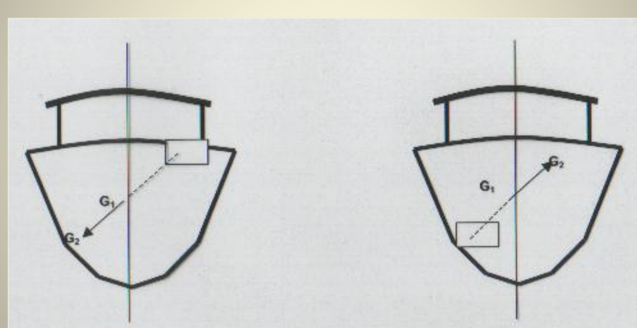
Movement Of Centre Of Gravity

Weight Discharged



Centre of Gravity moves <u>AWAY</u> from discharged weight (From G1 to G2)

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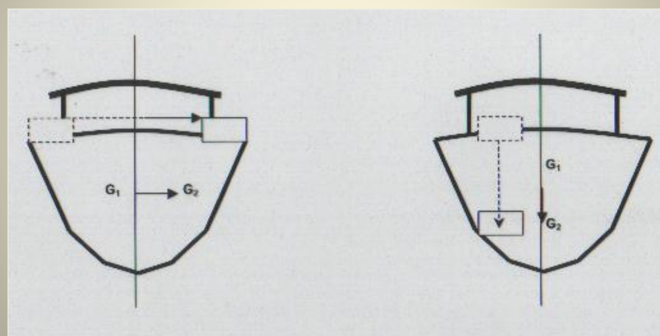
Movement Of Centre Of Gravity

Weight Shifted



Centre of Gravity moves PARALLEL to the movement of a weight which is already on board (From G1 to G2)

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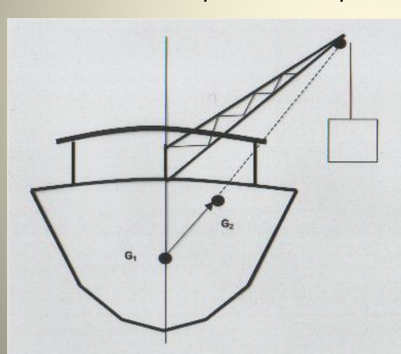
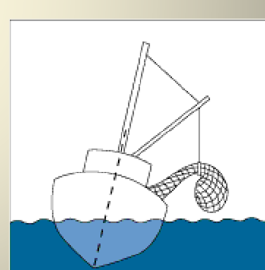
Movement Of Centre Of Gravity

Suspended Weights

The effect of a weight suspended from a boom is as if the weight were situated at the point of suspension





Centre of Gravity moves from G1 to G2

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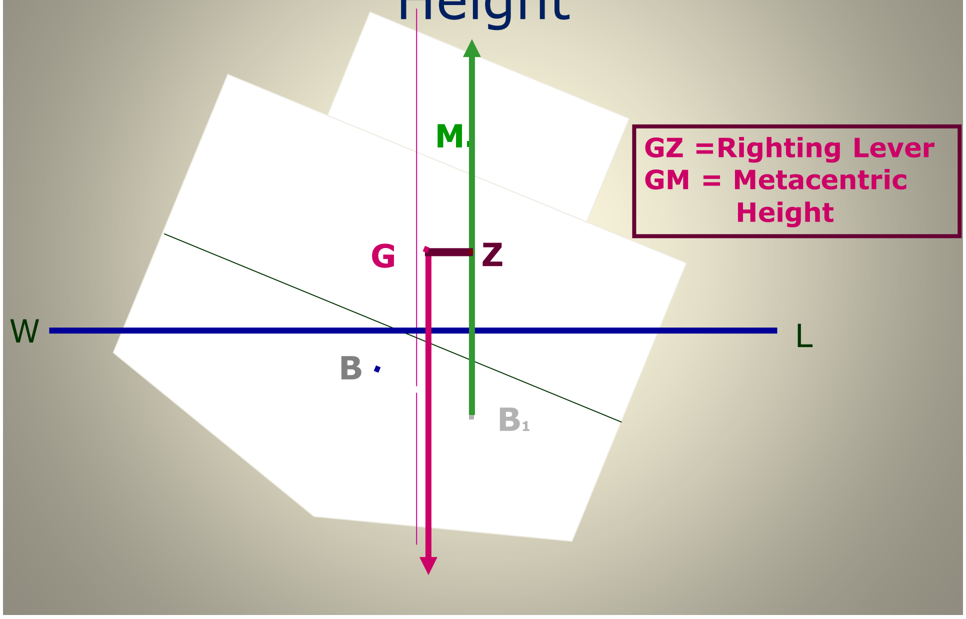
Righting Lever and Metacentric Height



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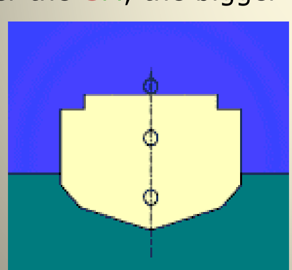
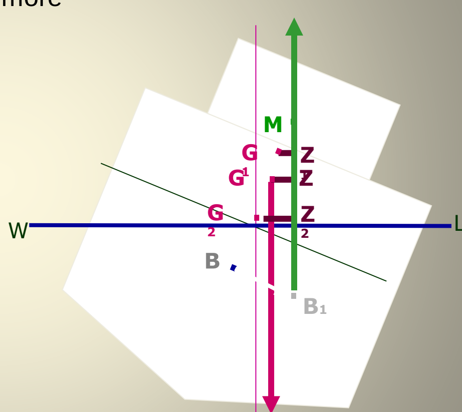
Does the size of the Righting Lever (GZ) change when the Centre of Gravity (G) is raised or lowered within the vessel?

- The bigger the Righting Lever, the more stability a vessel will have
- Size of Righting Lever is dependant on position of G
- GM and GZ are related - the bigger the GM, the bigger the GZ





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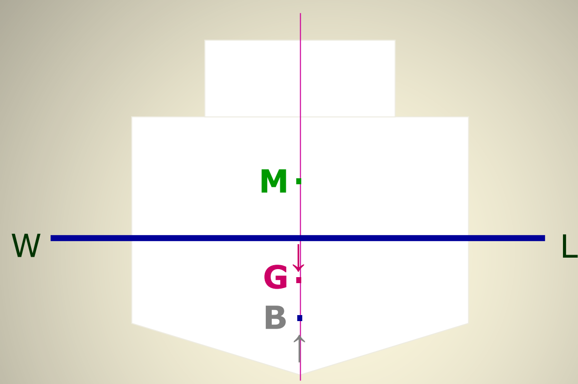
Equilibrium



- A vessel will float when the forces of weight and buoyancy are equal, and they balance
- In other words, B and G are in the same vertical line, and the vessel is not being acted on by an external force

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EQUILIBRIUM

- **Stable** Equilibrium
- **Unstable** Equilibrium
- **Neutral** Equilibrium

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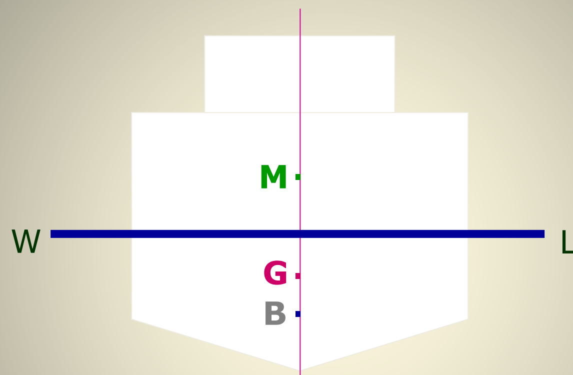
Stable Equilibrium



- Ship is in <u>Stable Equilibrium</u> if when inclined she returns to the upright
- CENTRE OF GRAVITY is <u>below</u> the METACENTRE (Positive "GM")
- "GM" = Metacentric Height

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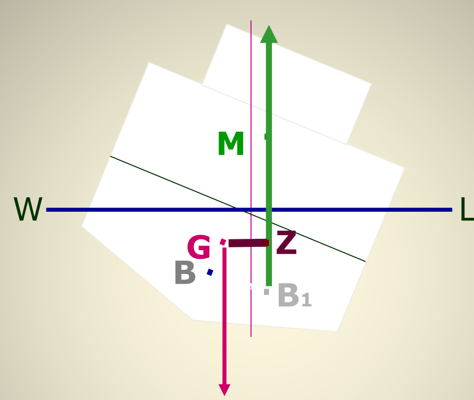
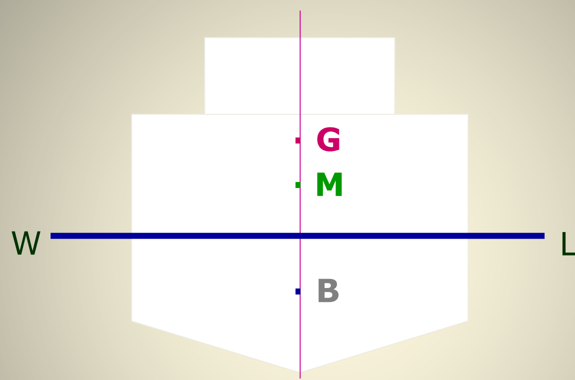
Stable Equilibrium



- When heeled, centre of buoyancy moves to B1
- Weight of ship pushes down through G
- Force of buoyancy pushes up through Z (from B1)
- Lever GZ experiences a turning moment (anticlockwise)
- Ship returns to upright position

266

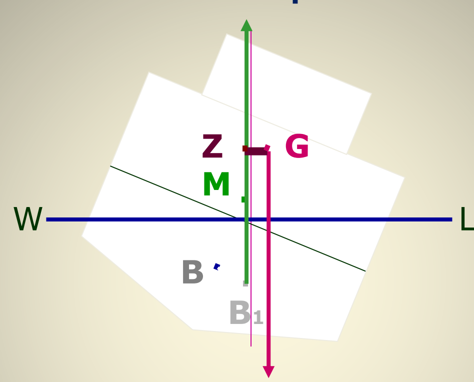
Unstable Equilibrium



- CENTRE OF GRAVITY is <u>ABOVE</u> the METACENTRE
- Negative “GM”

267

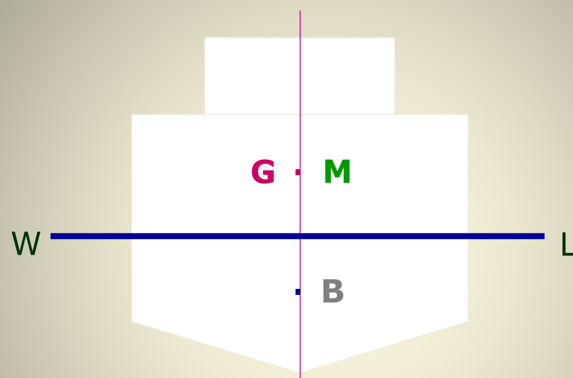
Unstable Equilibrium



- Vessel will not remain upright
- Centre of buoyancy moves to B1
- Force of buoyancy pushes up through Z (from B1)
- Weight of ship pushes down through G
- Lever GZ experiences a turning moment (clockwise)

268

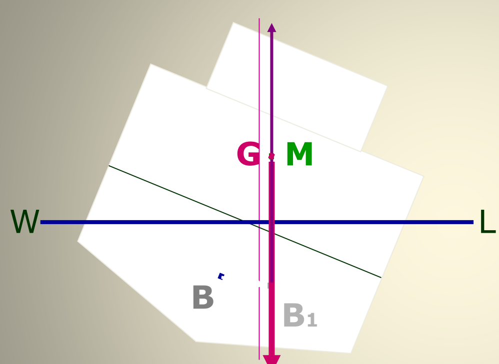
Neutral Equilibrium

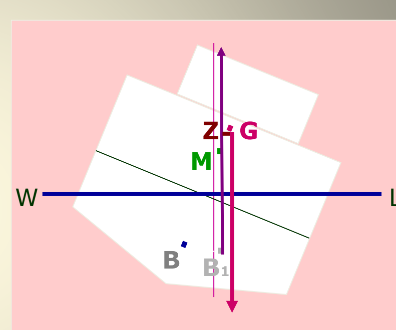


- CENTRE OF GRAVITY and METACENTRE coincide (ZERO "GM")
- Vessel has no reason to stay upright
- If heeled, vessel will have no tendency to either heel further or to return to the upright

269

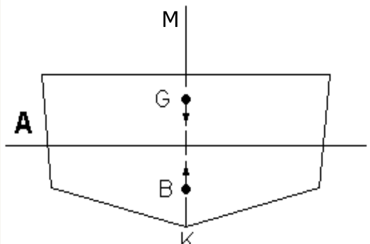
Neutral Equilibrium



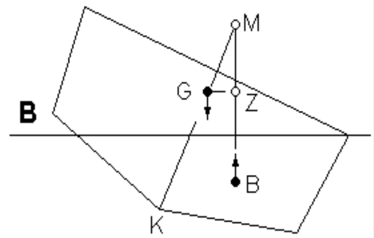


- **In theory, vessel will stay at any angle where placed (zero GZ)**
- *In practice, vessel will settle to some small angle of LOLL (because of increasing waterline beam as she rolls)*
- *Neutral equilibrium can be treated same as an Unstable Vessel*

270



Stable Equilibrium



Stable Equilibrium

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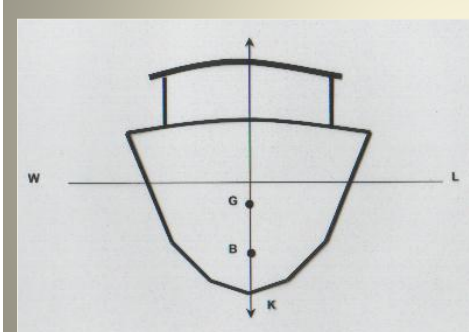
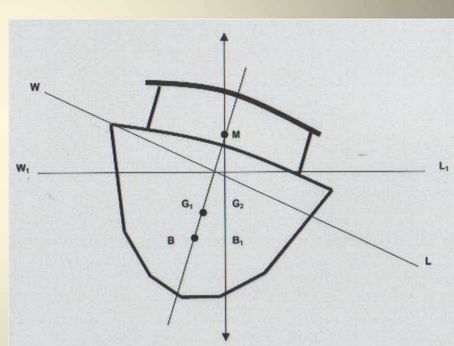
List

If weights are loaded, discharged or moved within the vessel, G may move off the centre line



No List



Vessel Listed

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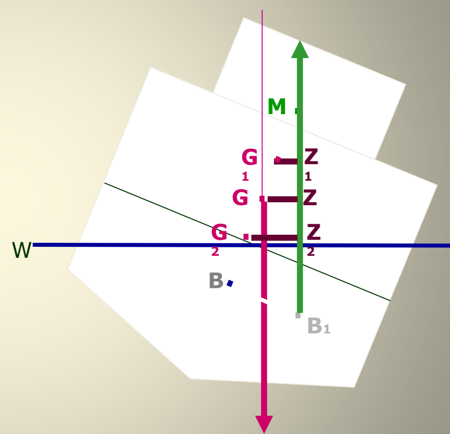
Stiff And Tender Vessels

Signs of a Stiff Vessel

- Plenty of Stability
- Big GZ and GM
- Has a quick and violent roll
- May be uncomfortable

Signs of a Tender Vessel

- Less Stability
- Small GZ and GM
- Long, slow easy roll
- Slow recovery



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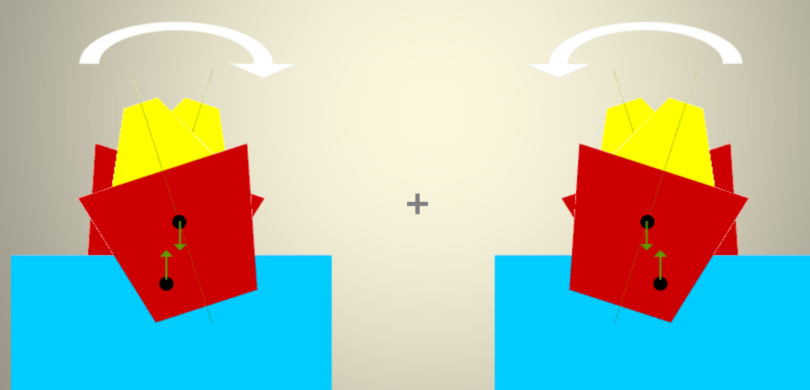
Roll Period

The time occupied in performing one double oscillation



What can the Roll Period tell us about a vessel's stability?

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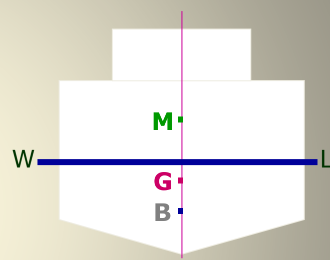
Roll Period



- **All vessels have a natural roll period**
- **Roll period is dependant on:**
  - **(1) GM**
  - **(2) Beam of vessel**
- **If GM is large, the roll period is short**
- **If GM is short, the roll period is long**
- **Roll period is a good indicator of stability**
- **If GM *decreases* – Roll Period *increases***
- **If GM *increases* – Roll Period *decreases***

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To obtain an approx value of GM

- Select an area of calm water
- Secure loose weights and press up slack tanks
- Initiate roll, and obtain average time from several rolls

Apply the following formula:

$$GM = \left(\frac{0.88B}{T}\right)^2$$

Where: B = Beam of vessel (metres)
T = Time for 1 roll (port-stbd-port) in seconds

(Answer will be in metres)

Compare this with information from your Stability Book

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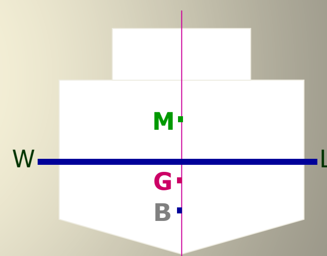
Weight Distribution

Remember

- **G** moves **towards** a **loaded** weight
- **G** moves **away** from a **discharged** weight
- **G** moves **parallel** to a **shifted** weight
- A suspended weight acts from the **point of suspension**



- Stability **improves** if **G** is **lowered**
- Stability gets **worse** if **G** is **raised**
- **Free surface effect** makes stability **worse**

What is Free Surface effect?

277

Free Surface Effect

The transverse movement of a fluid (liquids such as fuel, fresh water and water on deck and any other loads that can move) when a vessel is heeled causes free surface effect. It can cause a vessel to behave tender or, in the extreme, unstable.

If a fluid moves transversely when a vessel is heeled, the following occurs:

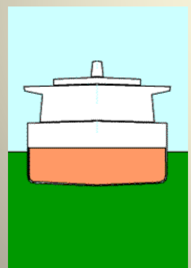
- The centre of gravity of the fluid load shifts transversely.
- The centre of gravity of the vessel moves parallel (temporarily off the centre line.
- The GZ lever is shortened, causing the righting moment to weaken and the roll period to lengthen.
- The vessel behaves like a tender vessel even though the metacentric height (GM) has not shortened.

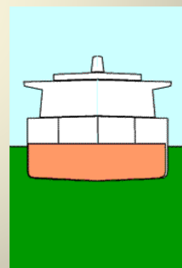
If the vessel was initially tender, the vessels centre of gravity could move outboard of the force of buoyancy, in which case the vessel would behave unstable and could roll over.

278

Free Surface Effect

- Liquids in a partially filled tank have a free surface, which is free to slop backwards and forwards with the motion of the ship
- Centre of Gravity moves from side to side
- Can cause a serious stability problem if movement of liquid is not contained





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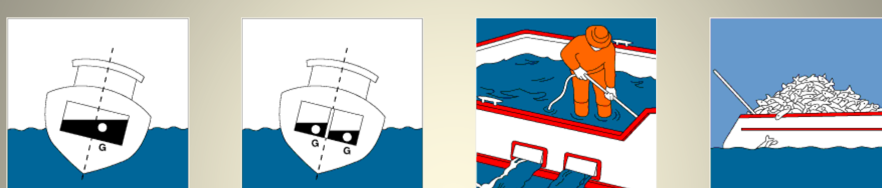
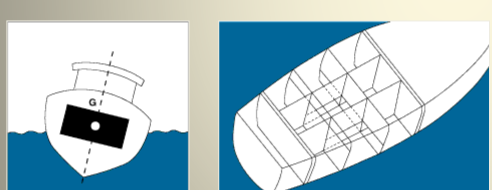
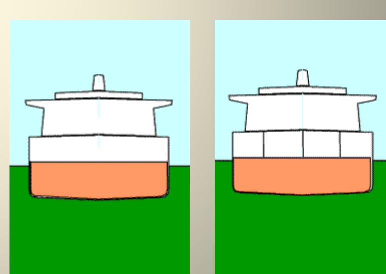
Free Surface Effect







- Slack tanks cause FSE
- To eliminate, either fill or pump out tank completely

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Free Surface Effect

How to minimise Free Surface Effect (you cannot avoid FSE completely)

- Tanks and fish holds etc should be subdivided with longitudinal bulkheads or baffles to reduce transverse fluid movement.
- During construction, tanks should be as small as practical and large single tanks avoided.
- Some vessels (such as yachts) may be constructed with hollow keels.
- Keep bilges dry and free of any liquid.
- Ensure decks clear water quickly, scuppers and freeing ports unobstructed,
- Minimise the number of partially filled (slack) tanks. Carefully manage consumption of fuel and water, empty a tank before drawing from another.
- Secure load against movement.

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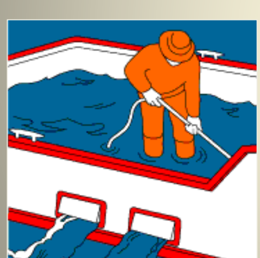
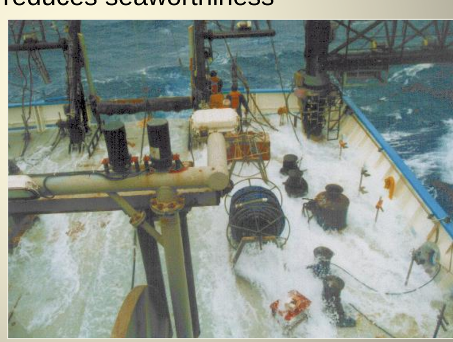
Stability Problems

Water on Deck

- Weight high up, reduces stability
- FSE of water, reduces stability
- Weight reduces freeboard, reduces seaworthiness





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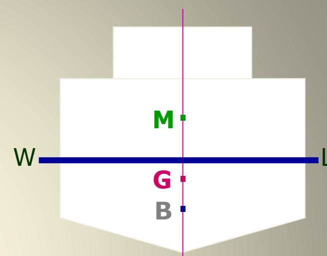
Weight Distribution

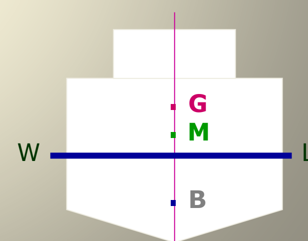
Stability is improved if:

- Weights already on board are lowered
- Weights are added low down
- High weights are removed
- Suspended weights are lowered
- Tanks are kept full or completely emptied



Stability is worsened if:

- Weights already on board are lifted higher
- Weights are added high up
- Weights are removed from low down
- Weights are lifted on booms
- Many tanks have free surfaces



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Study Note

- Explain the effect of taking on a large volume of seawater into the bilge when at sea in a heavy swell.

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LONGITUDINAL STABILITY

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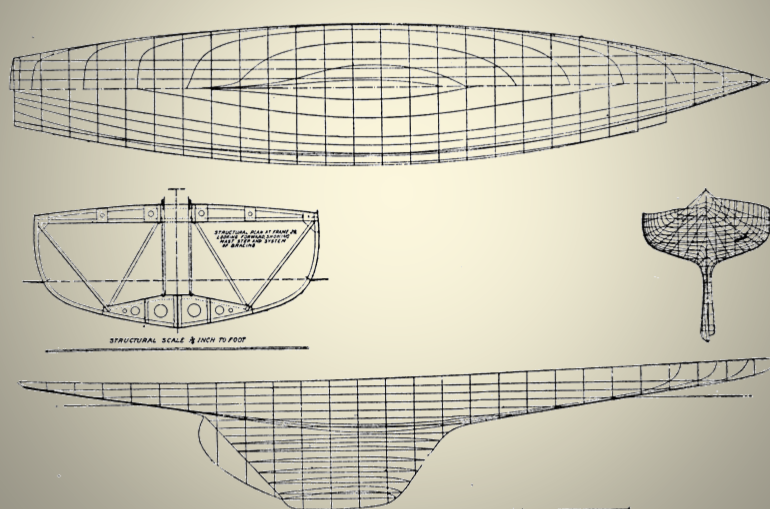
Longitudinal Centre Of Floatation “LCF”



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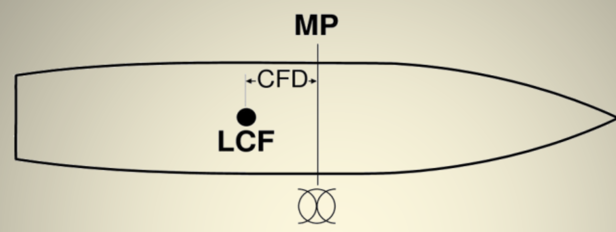
Longitudinal Centre Of Floatation "LFC"



LCF - The Longitudinal Center of Flotation

Longitudinal Centre of Floatation

- Centre of underwater waterline shape at which the vessel floats
- LCF is behind the vessel's centre line (midships) due to hull shape
- Vessel rotates about LCF when it trims

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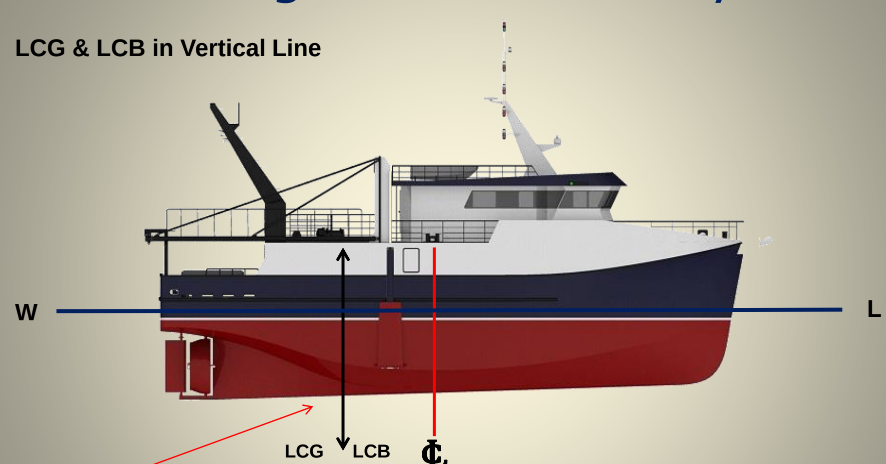
Longitudinal Stability

LCG & LCB in Vertical Line



When the **Longitudinal Centre of Gravity (LCG)** and the **Longitudinal Centre of Buoyancy (LCB)** are in the same vertical line – there is **No trimming moment**

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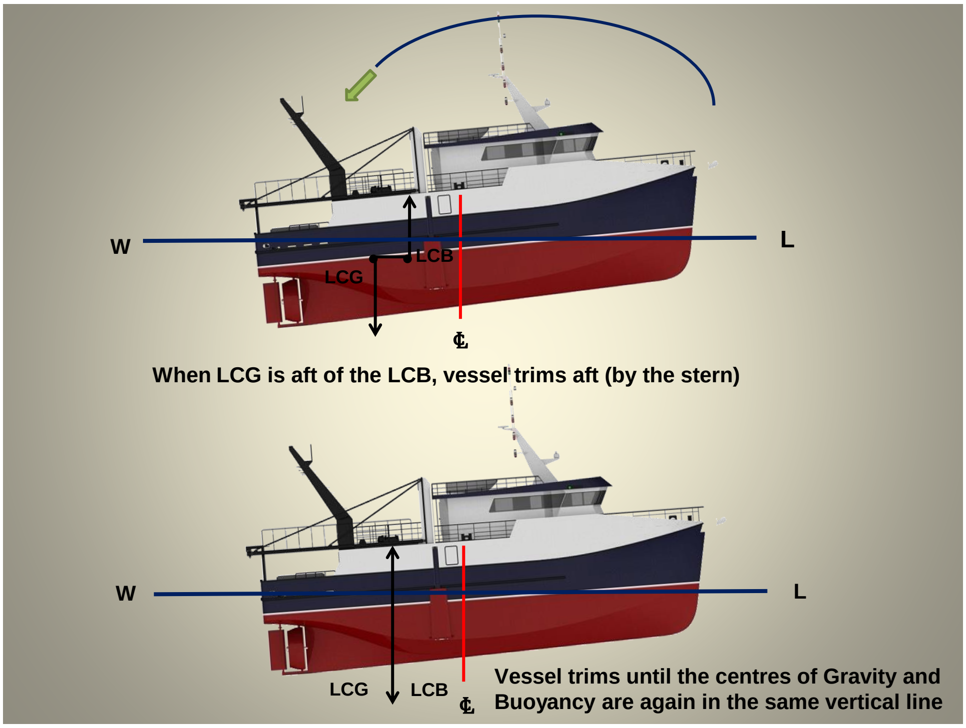
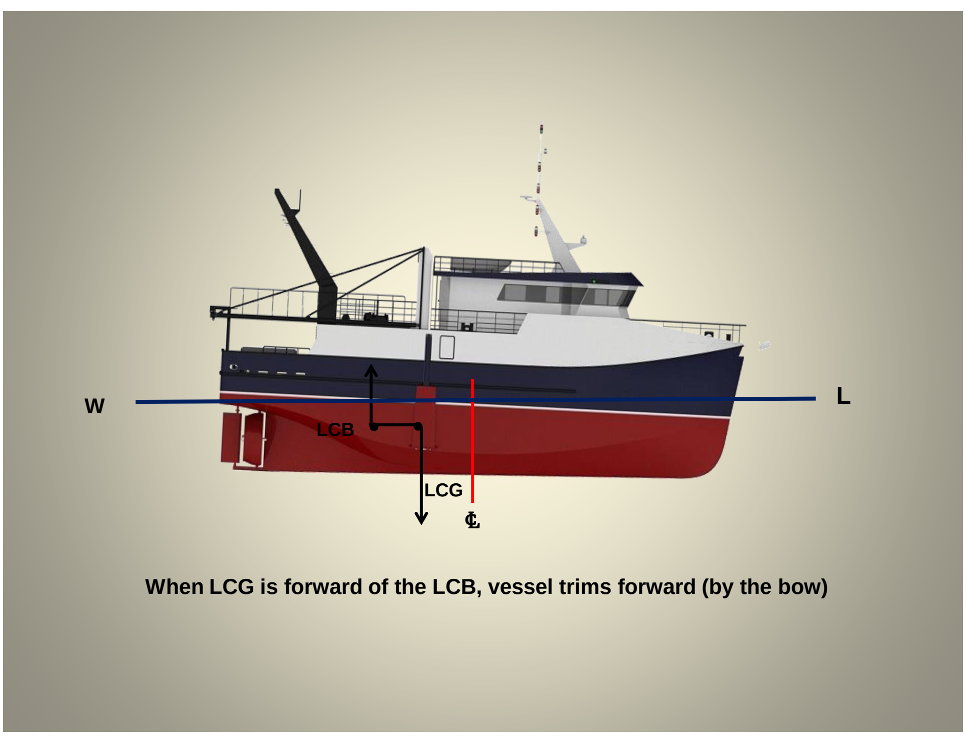
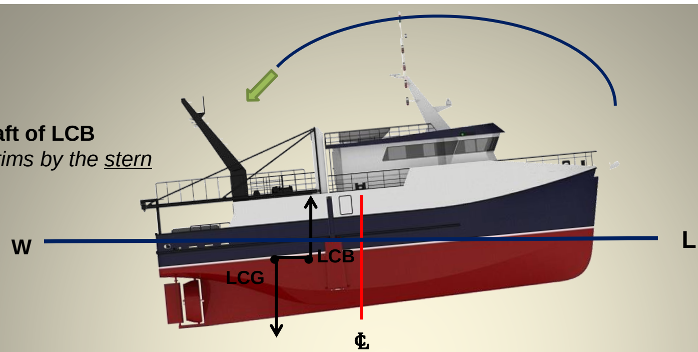

W
L
LCB
LCG
℄
When LCG is aft of the LCB, vessel trims aft (by the stern)
W
L
LCG
LCB
℄
Vessel trims until the centres of Gravity and
Buoyancy are again in the same vertical line

289


W
L
LCB
LCG
℄
When LCG is forward of the LCB, vessel trims forward (by the bow)

290

LCG is aft of LCB
Vessel trims by the stern



When LCG is aft of the LCB, vessel trims aft (by the stern)

It is desirable to trim your vessel by the STERN
- *Increased reserve buoyancy forward*
- *Vessel will ride more comfortably over head seas*
- *Rudder more responsive, vessel will handle better*

However,
Excessive trim by the stern is not good
- *Vessel becomes over responsive*
- *Considerably less stable*

Stability calculations for safe operation are based on the assumption that the vessel is on an even keel (equal drafts fore and aft)

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Suspended Weights

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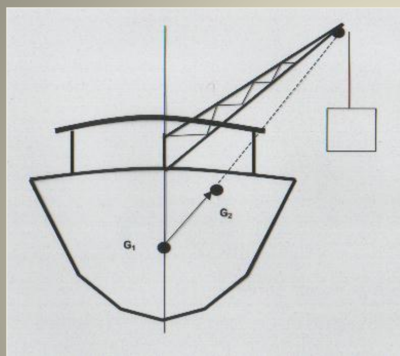
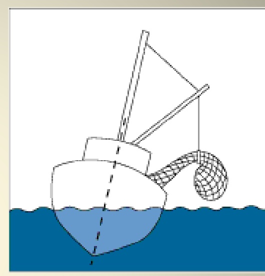
Suspended Weights





- When lifted by a crane, <u>COG of Weight</u> is immediately transferred to the head of the crane
- Centre of Gravity moves from G1 to G2
- The COG of the weight will not change further, no matter how high (or low) the weight is lifted/lowered

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Suspended Weights

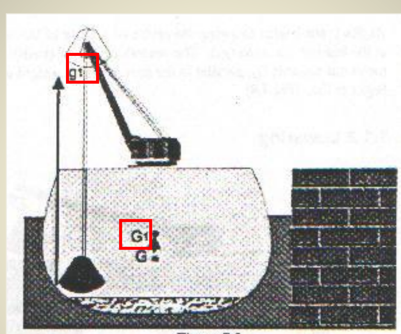

Figure 7.3

<u>Example</u>

- As weight is lifted, <u>COG of Weight</u> moves to top of crane (g1)
- <u>COG of Vessel</u> also moves parallel and upwards to G1
- COG's of g1 and G1 will remain during the whole time the weight is being raised

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Suspended Weights

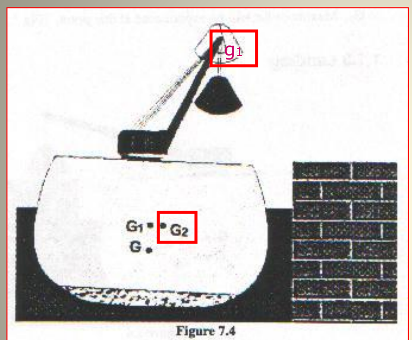

Figure 7.4

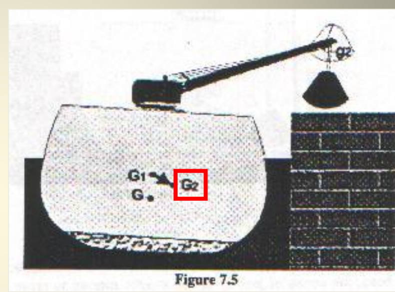

Figure 7.5

- As weight is swung, COG of Weight remains at top of crane (g1)
- COG of Vessel also moves parallel to the weight and outwards to G2
- As boom is lowered, COG of Weight moves down with crane
- COG of Vessel also moves parallel to the weight to G2

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Suspended Weights

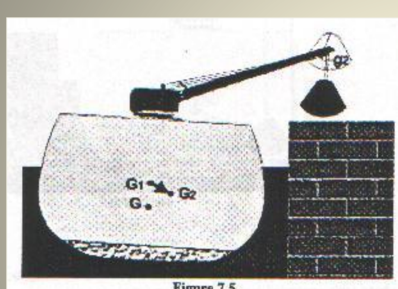

Figure 7.5

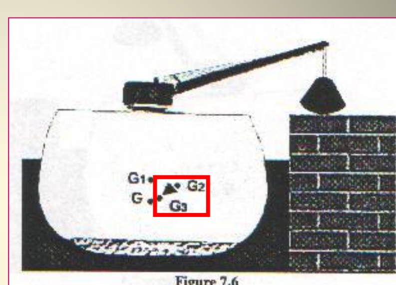

Figure 7.6

- As weight is discharged onto wharf, COG of Weight disappears
- COG of Vessel moves directly away from the crane head from G2 to G3

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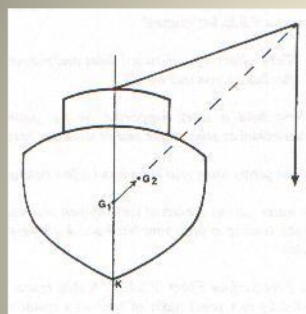
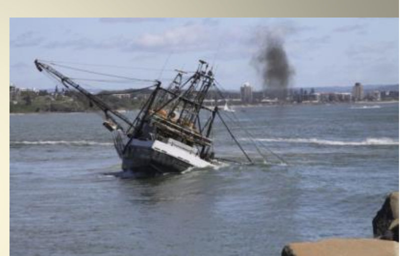
Loads on Fishing Gear



- When lifting or trawling, force exerted by the weight/tow will be felt at the point of suspension (end of boom)
- Can be detrimental to stability
- Vessel design should incorporate good stability

297

Snagged Gear (Trawler)



- Capsize is not far away !!
- If the gear holds – you can wind yourself over!!
- Use the main engine wrongly - you'll go over!!

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Snagged Gear – What to Do

- Get the weight off the gear.
- Get the line inboard from the booms
- Get the line amidships over the stern.
- Secure the line so it stays amidships.
- Decide what action is next appropriate.

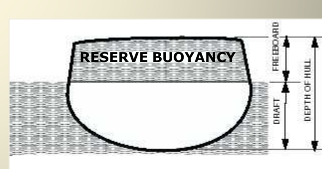
e.g – back away, cut the gear, increase engine power.

299

Stability Problems

Bilging: (*water entering a compartment holed below the waterline)*

- As weight increases, freeboard and reserve buoyancy decrease
- Draft increases, Stability decreases
- When reserve buoyancy is gone, vessel sinks



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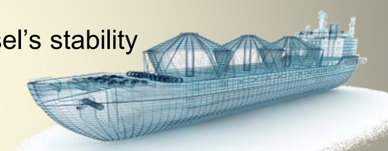
Stability Problems

Structural Changes

- Extra added gear, particularly high up, may effect stability
- Requires Naval Architect to review vessel's stability calculations



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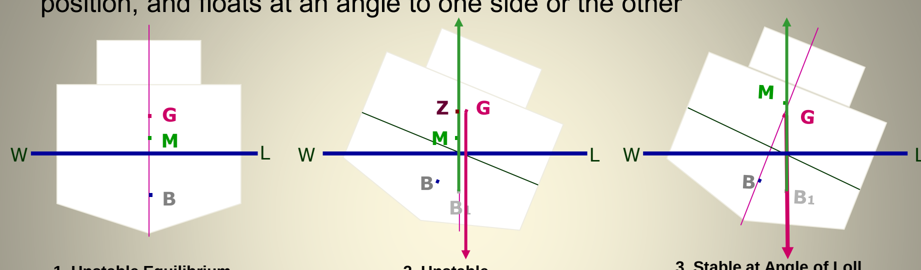
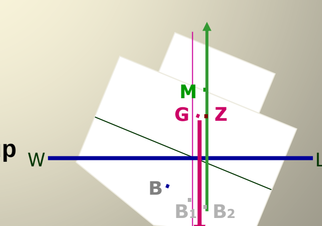
Angle of Loll

ANGLE OF LOLL - "A vessel which is unstable when in an upright position, and floats at an angle to one side or the other"



1. **COG is high**
2. **Vessel flops to one side**
3. **New underwater shape shifts metacentre up**
4. **Vessel has slight stability at angle of loll**



4. Stable

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List or Loll?

List

- Shifting cargo
- Uneven distribution of fuel, water, cargo

Loll

- Vessel becoming progressively more tender
- Roll period and angle of roll steadily increase
- Progressive raising of Centre of Gravity
  - Loading weights on deck
  - Using fuel, water from low down in hull

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Correcting a Loll

Lower the Centre of Gravity

Either:

- Take Ballast
  - Low side first

  (this will initially make angle of loll worse, but will lower Centre of Gravity, resulting in increased stability)

or

- Remove the cause (jettison cargo)
  - *From high side first*

304

Study Note

- You are using a crane to lift weights from the wharf onto your vessel during loading operations. What affect will this have on the vessels stability?

305

Vessel Design Considerations

Seaworthiness And Stability

The vessel must be designed to ensure that it is capable of surviving the variety of weather and operating conditions likely to be encountered in its area of operation. The vessel should have sufficient stability to keep it upright and afloat.

Six fundamental general design requirements:

- To float at an acceptable draught and trim.
- To be stable at all design draughts and trims.
- To be capable of withstanding reasonable stress of weather and handling conditions.
- To be capable of maintaining watertight integrity
- To be seaworthy in the waters in which the vessel is to be operated
- To be capable of safely performing the design task

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Vessel Design Considerations

Watertight Integrity

A vessels watertight and weathertight integrity is critical to its general seaworthiness and ultimately, to its ability to remain afloat. In general terms, surveying authorities require the vessel to be watertight below the freeboard deck and weathertight above the freeboard deck.

Watertight subdivision

A vessels hull is subdivided into a number of watertight compartments of which the number, location and vertical heights are nominated by the surveying authority. The purpose of subdivision is to limit permeation of the vessel and to prevent sinking should the vessel be holed. The concept of one compartment subdivision implies that, should the vessel be bilged in any one compartment, it will remain afloat and stable.

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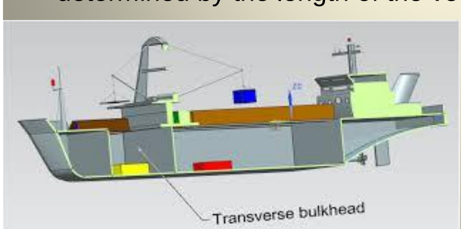
Vessel Design Considerations

Watertight Integrity

Watertight subdivision

Three general considerations in terms of subdivision:

- Watertight collision bulkhead in vessels over 16 metres in length.
- Watertight bulkheads to isolate the machinery space in vessels over 16 metres in length.
- Further subdivisions as required to ensure vessel maintains adequate buoyancy in the event of bilging (number of additional bulkheads determined by the length of the vessel)



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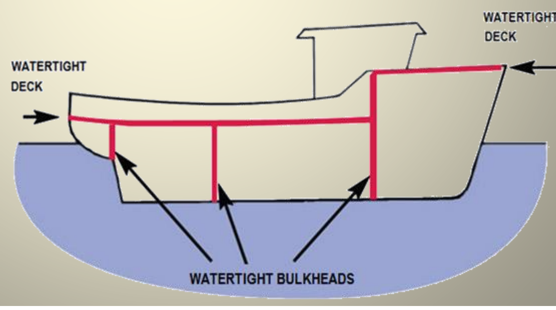
Vessel Design Considerations

Bulkheads

Bulkheads Provide;

- Watertight integrity
- Reserve buoyancy
- Divided spaces
- Strength
- Vessel shape
- Fire protection



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Maintaining Watertight Integrity and Stability

Given that watertight integrity is critical to seaworthiness and stability, general checks and inspections should be carried out as precautions:

A pre-departure check could include;

- Inspect bilges for water levels
- Be sure self-draining holes are clear
- Establish fuel and water tank levels
- Check load lines {if applicable} and weight distribution
- Ensure weights are kept as low as possible
- Check scuppers are clear
- Be sure all watertight doors are closed
- Keep all cargo secure to prevent movement and inspect lashings
- Secure loose items
- Ensure all hatch covers are closed

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Maintaining Watertight Integrity and Stability

Given that watertight integrity is critical to seaworthiness and stability, general checks and inspections should be carried out as precautions:

Coverage and frequency of checks and inspections whilst underway;

Checks and inspection frequency will vary depending on area and nature of operation, and can be altered depending on prevailing conditions.

- Allocate who will be responsible for inspections and when.
- As a general rule, checks should be conducted once every hour. Checks;

➢ Bilge levels
➢ Fuel and water tank levels
➢ Watertight doors and hatches are closed
➢ Weathertight air vents and vents are closed
➢ Anchor and deck fittings are secure
➢ Check cranes and crane hooks are secure
➢ Cargo lashings are secure, retighten if necessary
➢ Check scuppers and freeing ports are clear.
➢ Items in galley and accommodation spaces are secured
➢ Personnel access ways are rigged and secured

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Maintaining Watertight Integrity and Stability

Given that watertight integrity is critical to seaworthiness and stability, general checks and inspections should be carried out as precautions:

- Should you identify any irregularities or risks to watertight integrity whilst underway, you should take immediate and appropriate action to rectify the situation, provided this is within your ability to do so and prevailing conditions permit.
- If you encounter irregularities beyond your ability to rectify, immediately report the problem so that remedial action can be taken in a timely manner.
- Reports of each inspection round should be included in the ship or engineering log according to vessels operational procedures

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Maintaining Watertight Integrity and Stability

If whilst at sea you encounter deteriorating weather conditions, in addition;

- Consult Stability Book for information
- Check Bilge levels
- Reduce free surface effect from tanks
- Re-check scuppers are clear
- Keep day tank pressed up
- All openings must be closed, particularly watertight and weathertight doors, hatches, deck fittings and ventilation trunks. Ensure all vents are closed.
- Move cargo lower if possible, re check lashings and cargo security
- Secure loose items
- Ensure all hatch covers, seals and comings are in place
- Portholes deadlights closed
- Choose course and speeds to minimise synchronisation

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Study Note

- ➢ Can you outline the main purposes a bulkhead provides? {at least three}
- ➢ The skipper has asked that you hose down the vessels deck heads. What will you be washing?
- ➢ Sea water is washing over the transom. Where are you taking on water?

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