File: `ISOhexbolt.tex`

Definition 0.1 The sizes of ISO hex bolts are standardized by their internal thread (irrespective of the pitch) by the ISO.

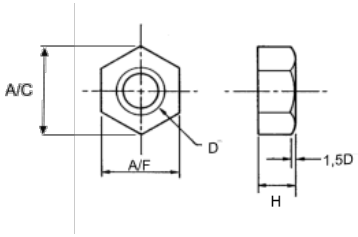
thread	flat size	diameter	height
M1		2.5 mm	
M1.6		3.2 mm	
M2	4 mm		1.6 mm
M2.5	5 mm		2 mm
M3	5.5 mm	6.4 mm	2.4 mm
M4	7 mm	8.1 mm	2.4 mm
M5	8 mm	9.2 mm	4 mm
M6	10 mm	11.5 mm	5 mm
M8	13 mm	15 mm	6.5 mm
M10	16 mm	19.6 mm	8 mm
M12	17 mm	22.1 mm	10 mm
M16	24 mm	27.7 mm	13 mm
M20	30 mm	34.6 mm	16 mm
M24	36 mm	41.6 mm	19 mm
M30	46 mm	53.1 mm	24 mm
M36	55 mm	63.5 mm	29 mm

File: `ISOhexnut.tex`

Type()ISO-hex-nut: $\mathbb{R} \to$ SObj

Definition 0.2 (ISO Hex Nut) The sizes of hex nuts are standardized by their internal thread (irrespective of the pitch) by the ISO.

thread	flat size	diameter	height
M1		2.5 mm	
M1.6		3.2 mm	
M2	4 mm		1.6 mm
M2.5	5 mm		2 mm
M3	5.5 mm	6.4 mm	2.4 mm
M4	7 mm	8.1 mm	2.4 mm
M5	8 mm	9.2 mm	4 mm
M6	10 mm	11.5 mm	5 mm
M8	13 mm	15 mm	6.5 mm
M10	16 mm	19.6 mm	8 mm
M12	17 mm	22.1 mm	10 mm
M16	24 mm	27.7 mm	13 mm
M20	30 mm	34.6 mm	16 mm
M24	36 mm	41.6 mm	19 mm
M30	46 mm	53.1 mm	24 mm
M36	55 mm	63.5 mm	29 mm



File: `ISOmetricthread.tex`

Definition 0.3 Straight threads are standardized by diameter d (in millimeters) and pitch p. A M$d \times p$ thread has one start, an angle of 60 °, pitch p, major diameter d and minor diameter $d \cdot \frac{(5\sqrt{3})}{8} \cdot p$.

The following threads are recognized by the ISO 261 standard: M1×0.25, M1.2×0.25, M1.6×0.35, M2×0.4, M2.5×0.45, M3×0.5, M4×0.7, M5×0.8, M6×1, M8×1.25, M8×1, M10×1.5, M10×1.25, M10×1, M12×1.75, M12×1.5, M12×1.25, M16×2, M16×1.5, M20×2.5, M20×2, M20×1.5, M24×3, M24 × 2, M30 × 3.5, M30 × 2, M36 × 4, M36 × 3, M42 × 4.5, M42 × 3, M48 × 5, M48 × 3, M56 × 5.5, M56 × 4, M64 × 6, and M64 × 4. The names of those threads that only exist in one pitch may be shortened by leaving out the pitch information.

Example 0.4 A M6 thread is really a M6 × 1 and has a major diameter of 6 mm, a pitch (and lead) of 1 mm, and a minor diameter of 4.917 mm.

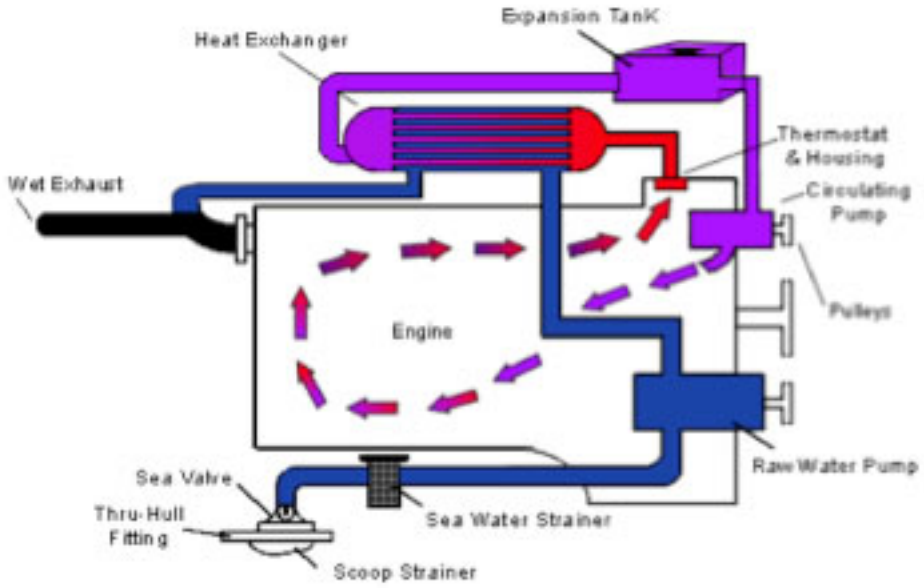
File: `color.tex`

Definition 0.5 The color of a physical object is defined by the spectrum of lights it emits or reflects. It is determined by the object's substance, its temperature and the spectrum of the incoming light.

File: `enclosed-cooling-system.tex`

Definition 0.6 (Heat Exchanger) A heat exchanger is a piece of equipment built for efficient heat transfer from one medium to another. The heat exchanger separates the media by a solid wall to prevent mixing.

Definition 0.7 (Enclosed Cooling System) An enclosed cooling system is a two-stage marine cooling system which uses a heatexchanger to separate the raw water from the fresh water (the engine coolant).



The coolant is circulated through the engine and a heatexchanger in a piping system and absorbs the heat of the engine. Raw water is still drawn up through a seacock but only flows through the heatexchanger. This cooler raw water absorbs the heat from the engine coolant through the heat exchanger and is then pumped out.

Definition 0.8 (Pump) A pump is a device that moves fluids (liquids or gases) by mechanical action.

Definition 0.9 (Water Pump) A water pump is a pump that moves water.

Definition 0.10 (Seacock) The seacock (also called through hull fitting) is a through-hull device that allows water to enter the hull from the outside. This device has a valve that allows you to shut off the water flow e.g. if you have a leak in the piping.

Definition 0.11 (Sea Strainer) The sea strainer is a device through which the raw water flows and is designed to filter out debris, sand, leaves, etc. before it gets to the engine. This device works much like a swimming pool skimmer.

File: `financial-transaction.tex`

Definition 0.12 A financial transaction is an agreement, communication, or movement carried out between two legal persons to exchange an asset (goods or services) for payment (usually a quantity of money called the transaction price or traded price). The legal person providing the asset in a transaction is called the seller (or vendor) and the legal person providing the payment the buyer.

A financial transaction is usually initiated by either an offer or a bid, which (after negotiations) leads to a transaction. Therefore we distinguish the asking price (the amount asked by the vendor) from the bid price (the quantity of payment offered by a buyer), which may differ from the transaction price.

Definition 0.13 A bid is a communication in which a potential buyer offers to buy a certain asset for a given payment, the bid price.

Definition 0.14 An offer is a communication in which a potential seller offers to buy a certain asset for a given payment, the asking price

Definition 0.15 If a financialtransaction contains more than one position, then we distinguish the individual price of a position from the overall price of the transaction, which often the sum of all individual prices.

Definition 0.16 If we do not want to distinguish between bid price, offer price, transaction price, individua price, and overall price we simply use the word price to mean any of them.

File: `five-sizes.tex`

Definition 0.17 The five-point size scale has the size constants XS (extra small), S (small), M (medium), L, (large), and XL (extra large).

File: `flange-bolt-gasket.tex`

Definition 0.18 A flange is an external or internal edge or rim on an object, e.g. a flange on a pipe as a connector.

Definition 0.19 A blind flange is a plate for covering or closing the end of a pipe, with a diameter larger than the pipe's.

Definition 0.20 A gasket is a mechanical seal which fills the space between two or more mating surfaces, generally to prevent leakage from or into the joined objects while under compression.

Definition 0.21 A flange gasket is a type of gasket made to fit between two sections of pipe that are flared to provide higher surface area, or between a pipe section and a blind flange.

Definition 0.22 A flange-bolt-gasket system is an assembly that covers or closes the flared end of a pipe, consisting of a blind flange, a gasket that seals the space between the flange and the pipe, and a number of bolts that hold together the flange, gasket and pipe end.

File: `importsall.tex`

this is only for generating the graph

File: `nutbolt.tex`

Definition 0.23 A bolt is a type of fastener with a straight, external thread designed to mate with a complementary thread in a nut, a type of fastener with a hole with an internal thread.

Axiom 0.24 Nuts and bolts are almost always used together to fasten a stack of parts together. The two partners are kept together by a combination of their threads' friction, a slight stretch of the bolt, and compression of the parts.

Definition 0.25 The geometry of a nut is (largely) determined by its height and the flat size, i.e., the size of the wrench used to tighten it on a bolt.

There are many types of nuts: acorn, hex, or wing nut.

Definition 0.26 The acorn nut is a type of nut which gets its name from its shape. It is a nut that has a domed top to prevent contact with the external thread of the corresponding bolt.

Definition 0.27 The hex nut is a type of nut that has an internal thread and a hexagonal outer shape.

Definition 0.28 A wing nut is a type of nut with two large metal "wings", one on each side, so it can be easily tightened and loosened by hand without tools.

Definition 0.29 The geometry of a bolt is determined by its length, head, thread, and threadlength.

There are also many types of boltss: hex, or wing bolt.

File: `partnumber.tex`

Definition 0.30 An (inventory) part number is an identifier of a solid object for the purposes of inventory and pricing. The part number is determined by the type of the object and its characteristic properties, such as the thread (for nuts and bolts), the head type (for and bolts), color .

File: `physobj.tex`

The following definitions are circular, they describe very fundamental concepts that are very hard to properly define. We take a relatively naive approach here, where space-time is Euclidean and mater is made up by elementary particles.

Definition 0.31 Matter is generally anything that has mass and extent. Matter is said to exist in three principal states depending on the bonding of the particles that make up the matter:

- solid: the particles are tightly bound by forces that prevent movement against each other and make the matter rigit.
- liquid: the particles are bound less tightly by forces, so that the particles can move against each other but are still strong enough to full separation.
- gaseous: the particles are vastly separated from each other.

Definition 0.32 Gases and liquids are together called fluids

Definition 0.33 A (chemical) substance is a form of matter that has constant chemical composition and characteristic properties. It cannot be separated into components by physical separation methods, i.e. without breaking chemical bonds.

Definition 0.34 A physical object is a collection of particles (pieces of matter) taken to be one; an entity that can be perceived by the senses and acted upon. Physical objects are characterized by their extent in time and space and the matter they consist of.

Definition 0.35 The extent of a physical object is the space it takes up seen over time. This is taken to be a function from time into subsets of three-dimensional space.

Often the extent function is constant up to translations and rotations (moving the object around in space).

Definition 0.36 The geometry of a physical object (at a given point in time t) is the equivalence class of its extent at t under all euclidean translations and rotations.

File: `piping.tex`

Definition 0.37 A pipe is a tubular section or hollow cylinder, usually but not necessarily of circular cross-section, used mainly to convey fluids.

Definition 0.38 A piping (or piping system) is a system of pipes joined by welding, soldering, brazing, or via fittings. Pipings are used to convey fluids (liquids and gases) from one location to another.

Definition 0.39 A fitting is used in pipings to connect straight pipe sections, to adapt to different sizes or shapes, and for other purposes, such as regulating or measuring fluid flow.

Definition 0.40 A clean-out (also called a pipe end) is a particular fitting that allows access to the piping system for revision and cleaning. Clean-outs should be placed in accessible locations at regular intervals throughout a piping system. The minimum requirement is typically at the end of each branch in piping and at the base of each vertical stack.

File: `price-function.tex`

The price of an offer or a bid may vary with the amount of the asset. Therefore it is usually given as a function from quantities of goods to payments.
Type()price-function: $Q \to Q$

Definition 0.41 A price function is a function $v\colon Q \to Q$, which assigns a price $v(q)$ of a quantity q of an asset.

The simplest price function is the following:

Definition 0.42 The unit-based price function $p\colon Q \to Q$ with unit price u_1 for unit quantity q_1 is given as $p(q_1) := (q/q_1) \cdot u_1$

Often a price function comes in the form of a unit-based price function with a discount, which is given on a unit price for any purchase of a quantity that is above a given threshold.

Definition 0.43 A discount is a function $d\colon Q \to \mathbb{R}$ from (asset) quantities to real numbers. Given a price function p, it induces the discounted price function $p_d(q) := d(q) \cdot p(q)$.

Instead of discounting a whole price function, we can discount the unit price.

Definition 0.44 Given a discount d and a unit price u_1, the discounted unit price is the function $u_d^{u_1} : Q \to Q; q \mapsto d(q) \cdot u_1$.

Observation 0.45 *Given a discount d and a unit price u_1, the discounted price function induced by the unit-based price function is (the same as) the unit-based price function given by the discounted unit price.*

Usually, a discount comes as a step function.

Definition 0.46 If a discount d is a left step function, i.e. $d(q) = c$ for all $q_0 \leq q \leq q_1$ where q_0 and q_1 are adjacent step points. Then we call q_0 the minimum purchase for the price c.

In cases where a potential buyer has more than one offer (e.g. by multiple vendors) we use a price comparison function:

Definition 0.47 A price comparison function is a function $c\colon \mathrm{LP} \times Q \to Q$ such that $c(l, q) = p(q)$, where p is the price function of the current offer from vendor l.

File: `solidobj.tex`

Definition 0.48 A solid object is a physical object that is solid.

As the extent of solid objects is constant over time (unless subjected to external forces), we can speak of the shape of a solid object as its current extent.

Definition 0.49 The type of a solid object is usually characterized by classifying objects by their shape and substance.

File: `thread.tex`

Definition 0.50 A screw thread, is a helical ridge wrapped around (the inside or outside of a) cylinder or cone in the form of a helix, with the former being called a straight thread (external thread or internal thread) and the latter called a tapered thread.

A straight thread is characterized by its

1. major diameter, i.e. the largest diameter of the thread,
2. minor diameter, i.e. the largest diameter of the thread,
3. angle, i.e. the angle of the side of the ridge that makes up the thread,
4. pitch, i.e. the distance from one crest of the ridge to the next, and by
5. the number of starts, i.e. the number of ridges wrapped around the cylinder.

The lead of a thread is just its pitch times the starts.

References