Engineering Graphics

Freehand Sketches of Engineering Elements

6.1 Free Hand Sketches of Engineering Elements

Freehand sketching is the practice of drawing engineering elements and components quickly and reasonably accurately, by hand, without the use of drafting instruments such as a T-square, set squares, or compass. It is an essential skill for engineers, since it allows ideas, components, and modifications to be communicated quickly on site, during discussions, or while making rough design notes, well before a formal, instrument-drawn engineering drawing is prepared.

This section introduces the freehand sketching of a set of very commonly used engineering fastening elements: thread profiles, nuts, bolts, studs, set screws, washers, and common locking arrangements, along with their standard conventional representation as used in engineering drawings. (For branches other than Mechanical Engineering, the specific elements sketched should be adapted to be relevant to that branch, as directed by the concerned faculty.)

Thread Profile and Terminology

A screw thread is a helical ridge of uniform cross-section formed on the external or internal surface of a cylindrical (or, occasionally, conical) component, used to convert rotary motion into linear motion, or to provide a mechanism for fastening. The V-thread (and its close variant, the ISO metric thread) is the most common thread form used in general fastening applications.

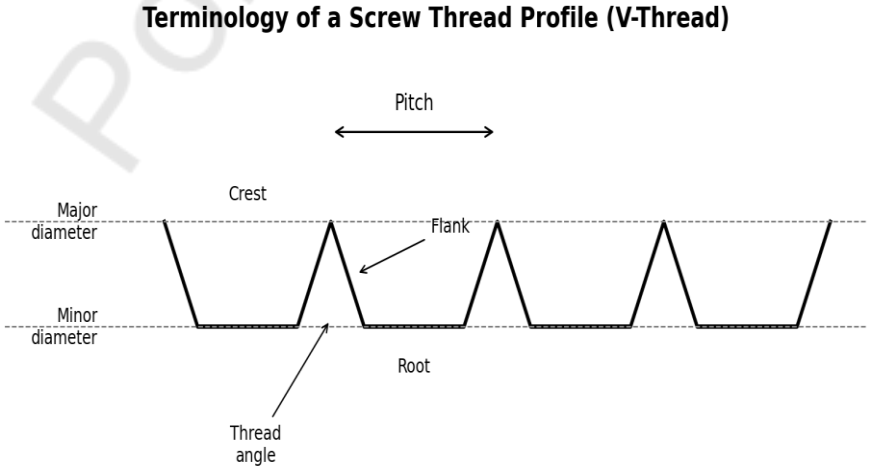

Figure 1: Terminology of a screw thread profile

The important terms associated with a screw thread, as illustrated in Figure 1, are:

- Major diameter: The largest diameter of the thread, measured at the crest (for an external thread) or at the root (for an internal thread).
- Minor diameter: The smallest diameter of the thread, measured at the root (for an external thread) or at the crest (for an internal thread).
- Pitch: The distance, measured parallel to the axis of the thread, between corresponding points on two adjacent thread forms.
- Crest: The topmost surface joining the two flanks of a thread, at the major diameter (for an external thread).
- Root: The bottommost surface joining the two flanks of a thread, at the minor diameter (for an external thread).
- Flank: The straight surface of the thread connecting the crest to the root.
- Thread angle: The angle included between the two flanks of the thread, measured in an axial plane (60° for the standard ISO metric thread).

Conventional Representation of Threads

Since drawing the exact helical form of a thread in every view would be extremely time-consuming and would add little practical value to an engineering drawing, threads are represented using a simplified, standardised conventional method, rather than their true, detailed geometric form. In this conventional method, the major and minor diameters are represented by two sets of parallel lines (of differing thickness), and the crest lines are indicated as short, thin, evenly spaced lines, without attempting to show the true helix angle.

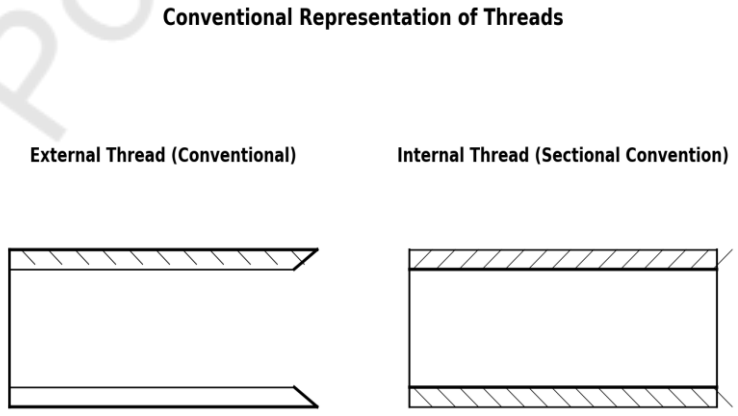

Figure 2: Conventional representation of an external thread (left) and an internal (sectional) thread (right)

As shown in Figure 2, in the conventional representation of an external thread, the major diameter is shown using thick continuous lines (representing the actual outer profile of the component), while the minor diameter is indicated with thinner lines. In a sectional view of an internal thread, this convention is effectively reversed: the minor (root) diameter of the internal thread is shown using thick lines, while the major diameter is shown using thinner lines, with hatching used to represent the solid material surrounding the threaded hole.

Common Fastening Elements

Beyond the thread itself, a range of standard fastening elements, each with characteristic proportions and conventional representation, are commonly encountered in engineering drawing and practice, summarised below:

Element	Description	Typical Application
Nut	A fastener with a threaded hole, usually hexagonal or square in outline, used together with a bolt or stud to clamp two or more parts together	Securing bolted or studded joints in machines and structures
Bolt	A cylindrical fastener with a head at one end and an external (male) thread at the other, passed through clearance holes in the parts to be joined and secured with a nut	General-purpose temporary or semi-permanent fastening of machine parts
Stud	A cylindrical rod threaded at both ends (and sometimes plain in the middle), with one end screwed permanently into a tapped hole in one part, while a nut is fitted on the other end to secure a second part	Joints requiring frequent dismantling of one part while the stud remains fixed, such as cylinder covers
Set Screw	A headless (or specially headed) screw, often with a slot, hexagonal socket, or square head, used to prevent relative rotational or sliding motion between two parts, such as a shaft and a pulley	Locking a collar, pulley, or gear onto a shaft
Washer	A thin, flat (or shaped) disc with a central hole, placed under the head of a bolt or nut	Distributing the clamping load over a larger area, protecting the surface, and (for spring washers) preventing loosening due to vibration
Locking Arrangement	A device or method used to prevent a nut or fastener from loosening due to vibration or repeated loading, such as a locknut, split pin, or spring washer	Ensuring fasteners remain secure in machinery subject to vibration, such as automotive and rotating equipment

Freehand sketches of these elements, along with common locking arrangements used to prevent fasteners from loosening under vibration or repeated loading, are illustrated below.

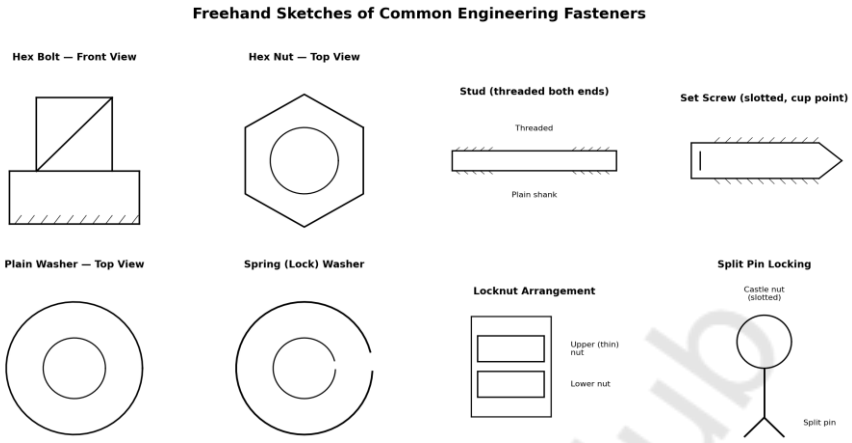

Figure 3: Freehand sketches of common engineering fastening elements and locking arrangements

As shown in Figure 3, hexagonal nuts and bolt heads are typically sketched showing their characteristic six-sided outline in the top view, and a rectangular outline (with the thread convention applied to the shank) in the front view. Washers are sketched as simple concentric circles (a plain washer), or with a small gap indicating the spring action (a spring/lock washer). Locking arrangements such as a locknut (two nuts jammed together) or a split pin passed through a slotted castle nut are sketched to clearly show how the mechanism prevents the primary fastener from working loose.

Regular practice in freehand sketching such elements, with attention to correct proportion, correct conventional representation, and reasonably neat line work, builds the visualisation skill and drawing fluency that underpins all further work in engineering graphics and technical communication.

2. Multiple Choice Questions (MCQs)

Answer the following questions by selecting the most appropriate option.

1. The major diameter of a screw thread refers to the diameter measured:

A) At the root of the thread
B) At the crest of the thread (the largest diameter)
C) At the mid-point of the flank
D) Along the pitch line only

2. The minor diameter of a screw thread refers to the diameter measured:

A) At the crest (largest diameter)
B) At the root of the thread (the smallest diameter)

C) Exactly midway between crest and root

D) Along the axis of the screw

3. The pitch of a screw thread is defined as the distance:

A) Between the crest and the root of the same thread

B) Measured parallel to the axis, between corresponding points on adjacent thread forms

C) Around the circumference of the thread

D) Between the major and minor diameters

4. In the conventional representation of an external (male) thread, the crest lines are generally drawn as:

A) Thick continuous lines equal in weight to the outline

B) Thin continuous lines, evenly spaced, representing the thread crests/roots

C) Dashed hidden lines only

D) Long dash-dot centre lines

5. In a sectional view, an internal (female) thread is conventionally shown with the root diameter drawn as:

A) A thin line, with the major diameter shown thick

B) A thick line, with the major (larger) diameter shown as a thinner line

C) Not shown at all

D) Only as a dashed line

6. A nut is generally distinguished from a bolt in that a nut:

A) Has an external thread and no head

B) Has an internal (female) thread and is used together with a bolt or stud

C) Is always smooth, without any thread

D) Is used only for electrical connections

7. A stud differs from an ordinary bolt mainly in that a stud:

A) Has a head at both ends

B) Is threaded at both ends, with one end permanently screwed into a tapped hole

C) Is never used with a nut

D) Has no thread at all

8. A set screw is primarily used to:

A) Join two plates using a nut

B) Prevent relative rotational or sliding motion between two parts, such as a shaft and a collar

C) Measure the diameter of a shaft

D) Replace the need for any other fastener

9. The primary function of a plain washer, placed under a bolt head or nut, is to:

A) Increase the thread pitch

B) Distribute the clamping load over a larger surface area and protect the material surface

C) Replace the need for a nut

D) Increase the diameter of the bolt

10. A spring (lock) washer is specifically designed to:

A) Increase the thread pitch of a bolt

B) Provide a spring action that resists loosening of the fastener due to vibration

C) Replace the need for a bolt entirely

D) Reduce the strength of a joint intentionally

11. A locknut arrangement, using two nuts on the same bolt, works by:

A) Simply doubling the weight of the assembly

B) Jamming the two nuts against each other, creating a locking friction that resists loosening

C) Removing the need for threads

D) Preventing the bolt from being tightened at all

12. A split pin, used with a castellated (slotted) nut, prevents loosening by:

A) Welding the nut permanently in place

B) Passing through a hole in the bolt and the slots of the nut, mechanically preventing rotation

C) Increasing the friction of the thread only

D) Changing the thread pitch

13. Freehand sketching of engineering elements such as nuts, bolts, and washers is primarily practised in order to:

A) Avoid learning correct proportions

B) Develop quick, accurate visualisation and communication skills, without relying on drafting instruments

C) Replace the need for orthographic and isometric drawing entirely

D) Only be used for decorative purposes

14. In freehand sketching, proportions between different features of a component (such as a nut and bolt) are generally maintained by:

A) Using precise instruments only

B) Estimating relative sizes by eye and comparison, using standard proportion guidelines

C) Ignoring proportion entirely

D) Copying an existing drawing exactly, without judgement

15. For branches other than Mechanical Engineering, freehand sketching practice is generally recommended to focus on:

A) The exact same fastener elements used in mechanical engineering only

B) Elements specific and relevant to that particular engineering branch

C) No freehand sketching at all

D) Only electrical circuit symbols regardless of branch

Answer Key

1. B) At the crest of the thread (the largest diameter) | 2. B) At the root of the thread (the smallest diameter) | 3. B) Measured parallel to the axis, between corresponding points on adjacent thread forms | 4. B) Thin continuous lines, evenly spaced, representing the thread crests/roots | 5. B) A thick line, with the major (larger) diameter shown as a thinner line | 6. B) Has an internal (female) thread and is used together with a bolt or stud | 7. B) Is threaded at both ends, with one end permanently screwed into a tapped hole | 8. B) Prevent relative rotational or sliding motion between two parts, such as a shaft and a collar | 9. B) Distribute the clamping load over a larger surface area and protect the material surface | 10. B) Provide a spring action that resists loosening of the fastener due to vibration | 11. B) Jamming the two nuts against each other, creating a locking friction that resists loosening | 12. B) Passing through a hole in the bolt and the slots of the nut, mechanically preventing rotation | 13. B) Develop quick, accurate visualisation and communication skills, without relying on drafting instruments | 14. B) Estimating relative sizes by eye and comparison, using standard proportion guidelines | 15. B) Elements specific and relevant to that particular engineering branch

3. Broad / Long Answer and Practical Questions

1. Define a screw thread, and explain the terms major diameter, minor diameter, pitch, crest, root, and thread angle, with the help of a labelled sketch.

2. Explain the need for a conventional (simplified) representation of screw threads in engineering drawings, rather than drawing their true helical form.

3. Sketch, freehand, the conventional representation of an external thread and an internal (sectional) thread, clearly distinguishing the major and minor diameter lines.

4. Sketch, freehand, the front view and top view of a hexagonal nut and a hexagonal-headed bolt, showing correct proportions.

5. Explain the difference between a bolt and a stud, and sketch a stud freehand, labelling its threaded and plain portions.

6. Sketch, freehand, a set screw with a slotted head and a cup point, and explain its typical application.

7. Sketch, freehand, a plain washer and a spring (lock) washer, and explain the difference in their function.

8. Explain, with a freehand sketch, how a locknut arrangement (two nuts on a single bolt) prevents loosening due to vibration.

9. Explain, with a freehand sketch, how a split pin used with a castellated (slotted) nut acts as a locking arrangement.

10. For your own engineering branch (if not Mechanical Engineering), identify three branch-specific engineering elements or components suitable for freehand sketching practice, and briefly describe each.