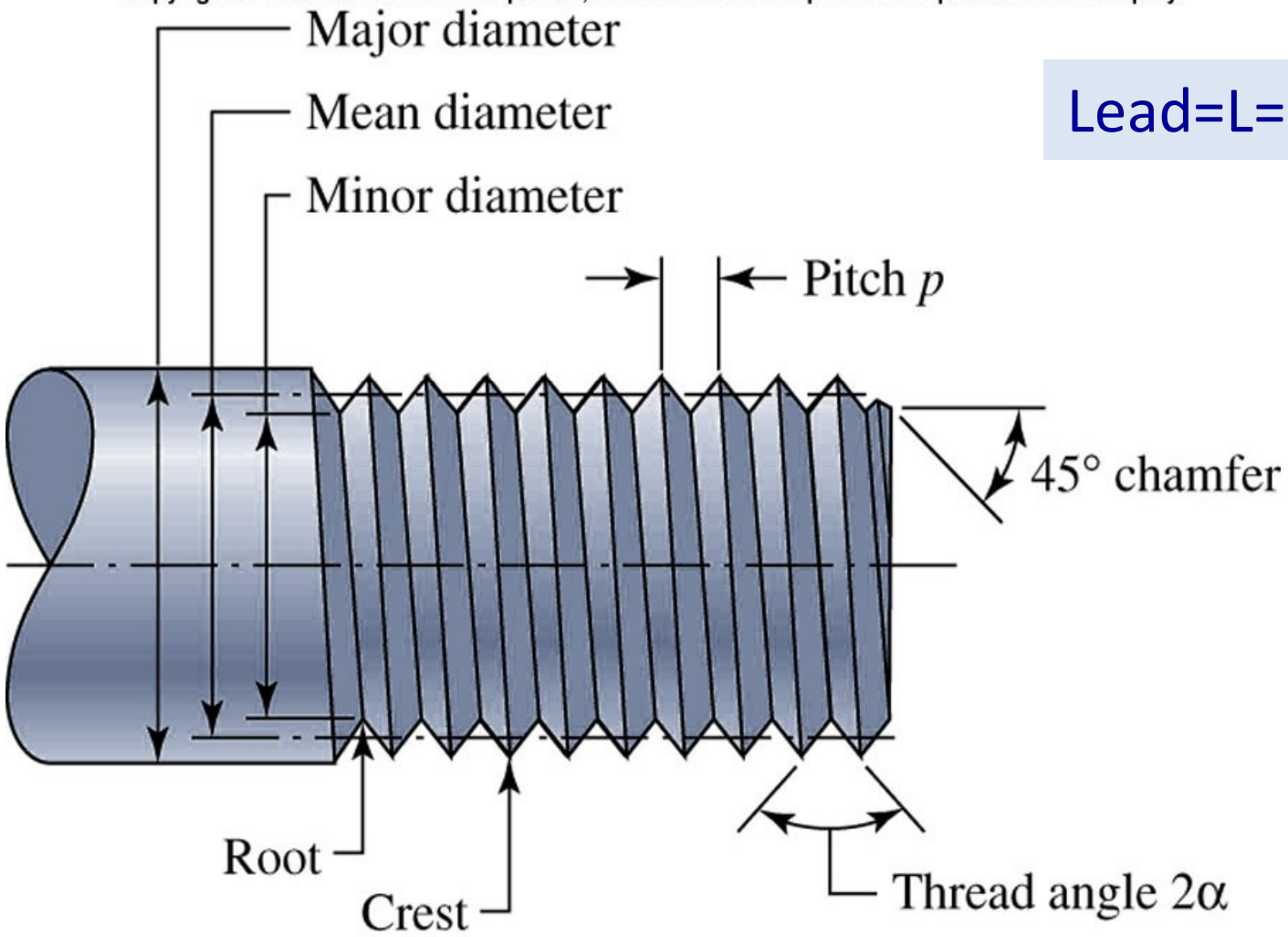
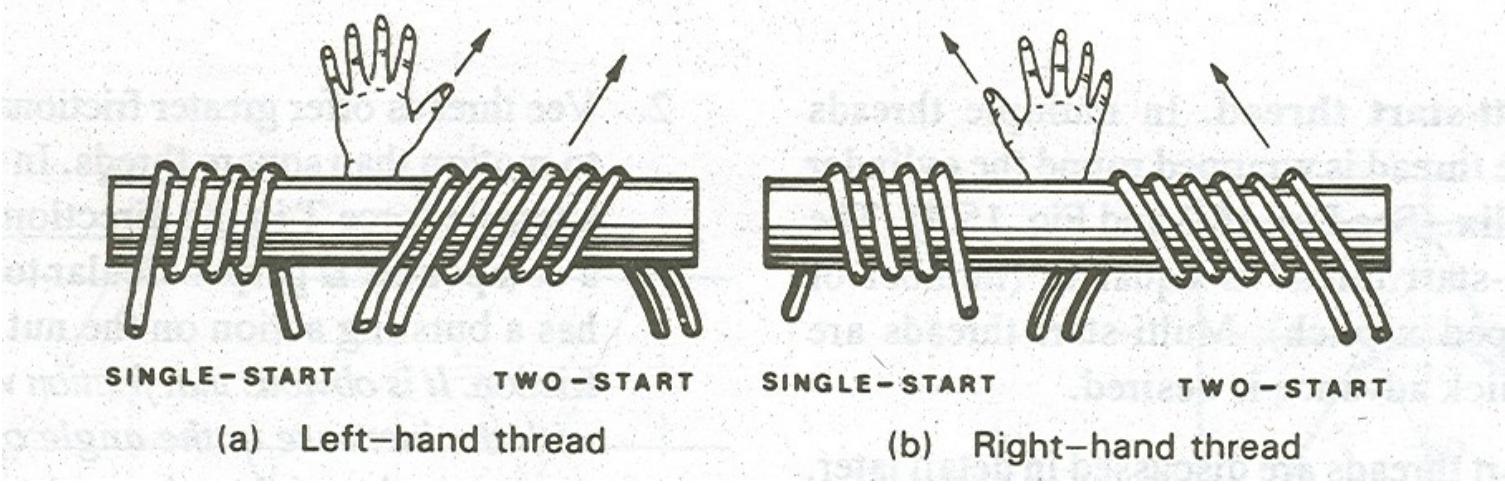
Chapter 8: Screws, Fasteners and the Design of Nonpermanent Joints

8-1 Thread Standards and Definitions



Lead=L=n p

Thread Conventions



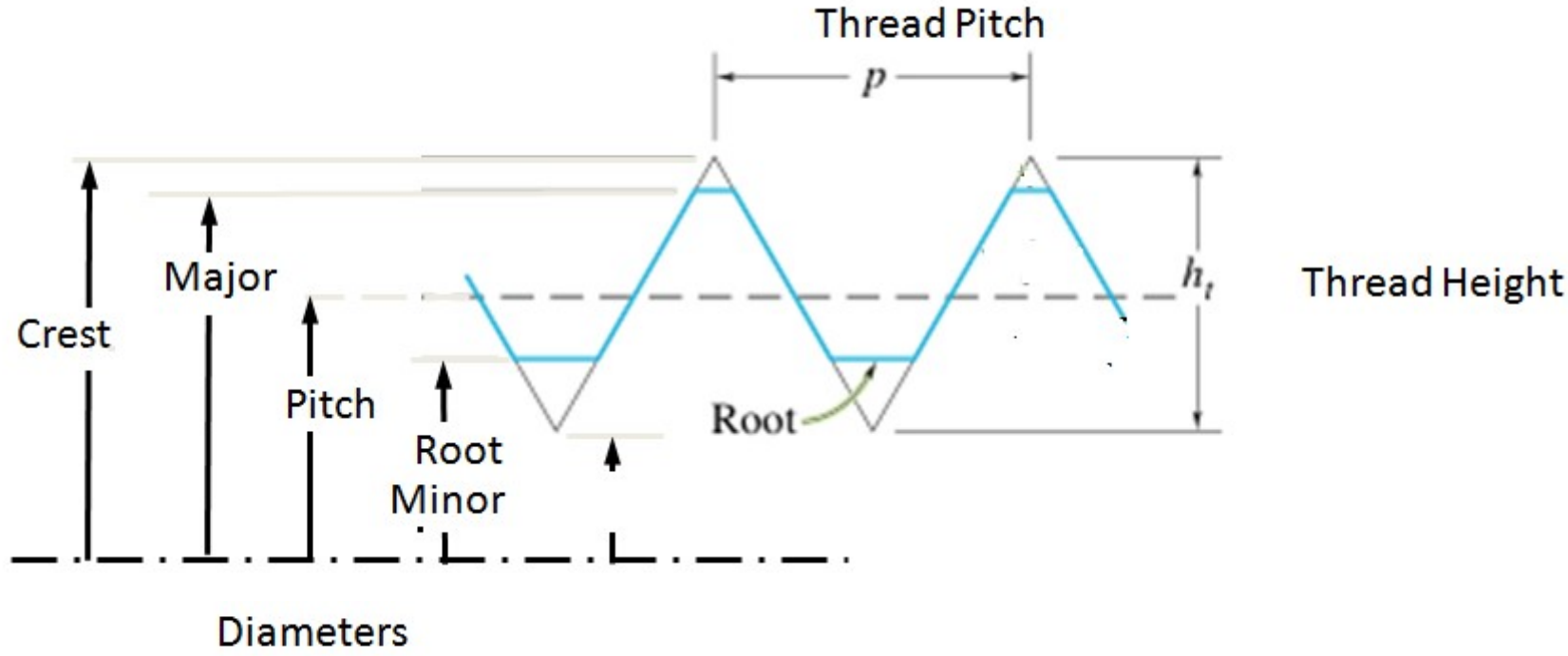
All threads are made according to the *right-hand rule unless otherwise noted.*

That is, if the bolt is turned clockwise, the bolt advances toward the nut.

Pitch: is the distance from a point on one thread to the corresponding point on the next.

Lead: is the distance the screw would advance relative to the nut in one rotation.
For a **single-thread screw**, **lead is equal to pitch**.
For a double-thread screw, **lead is equal to twice the pitch**.

- The major diameter (d) is the largest diameter of a screw thread.
- The minor diameter (d_r) is the smallest diameter of a screw thread.
- The pitch diameter (dp) is between the major and minor

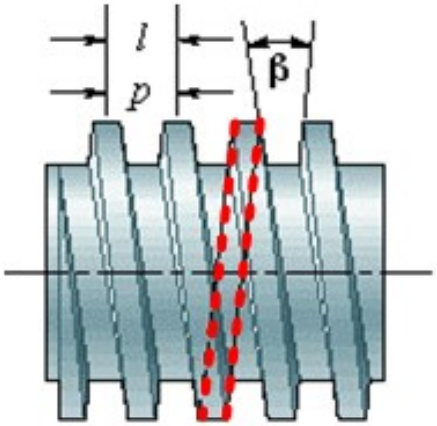


- Crest: The top surface.
- Root: The bottom Surface.
- Side: The surface between the crest and root.

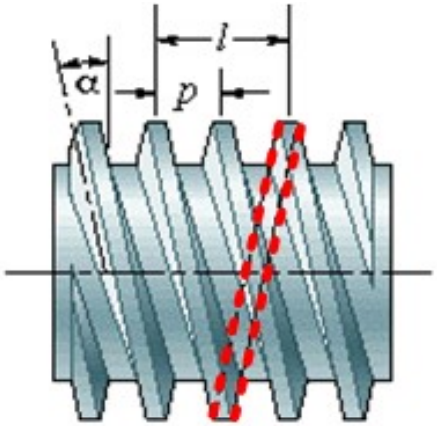
Lead = 1 x Pitch

Lead = 2 x Pitch

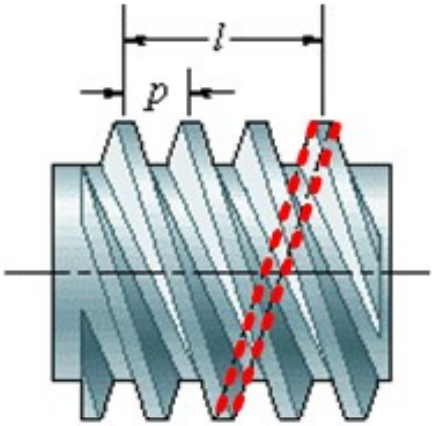
Lead = 3 x Pitch



(a)



(b)



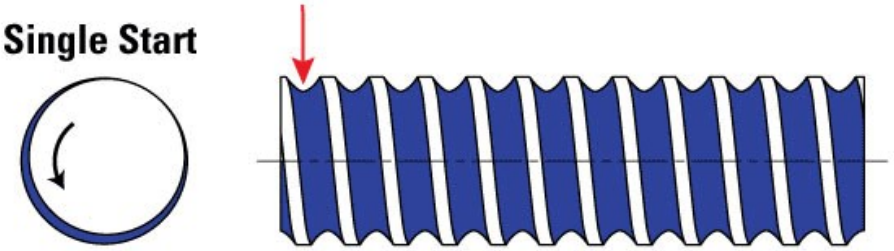
(c)

Single (**STANDARD**

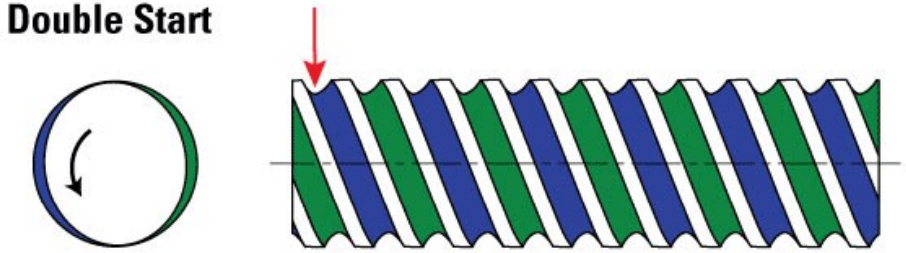
double

triple threaded

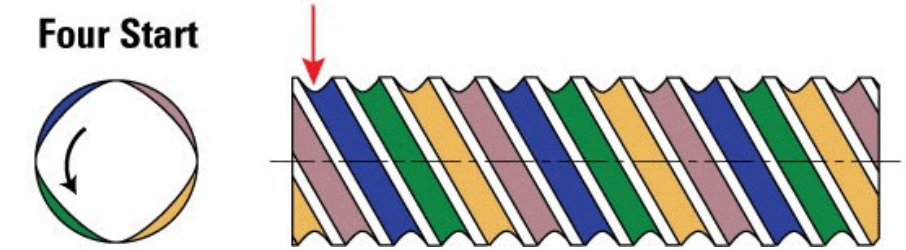
1 start

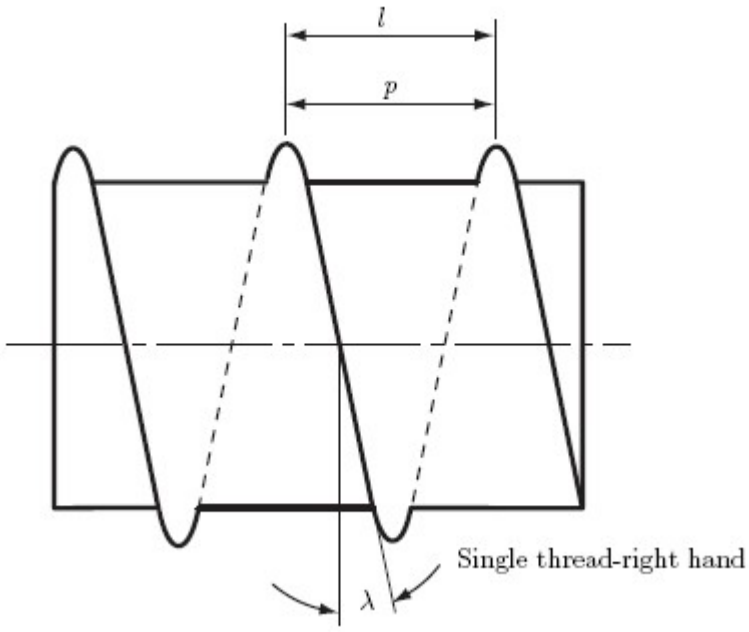


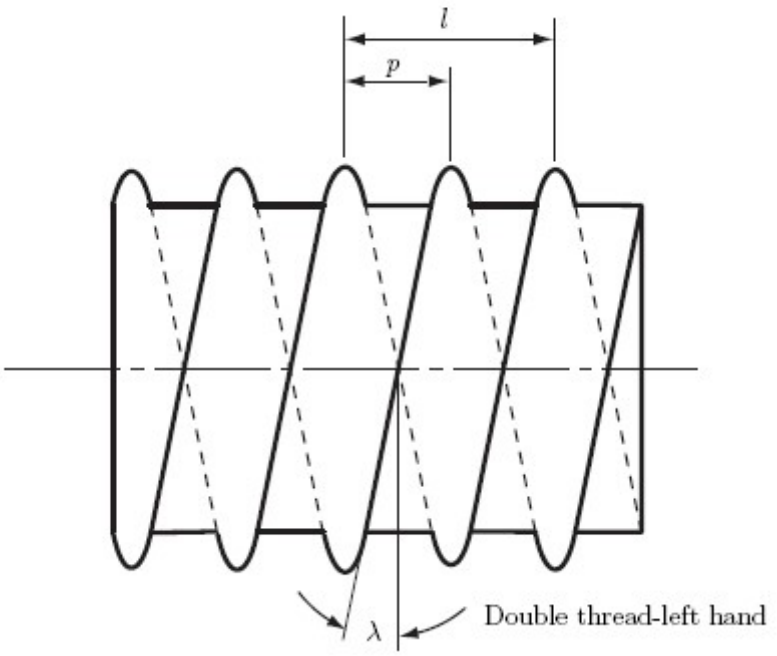
2 start



3 start




l
p
λ
Single thread-right hand

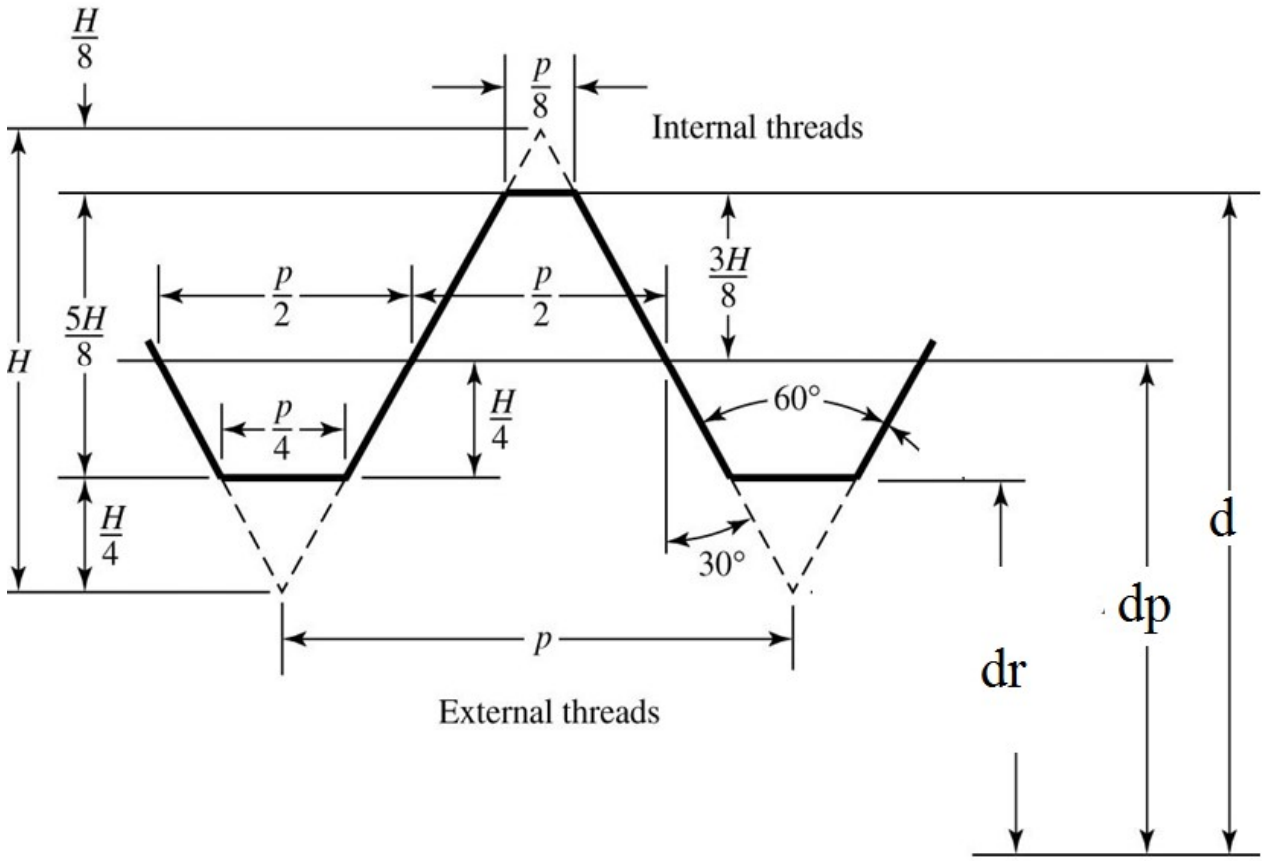

l
p
λ
Double thread-left hand

$H = 0.5(3)^{1/2}\, p$

US N= # threads/in

The thread angle is 60◦ and the crests of the thread may be either flat or rounded.

a ISO 68= a American National (Unified) thread standard= 60°



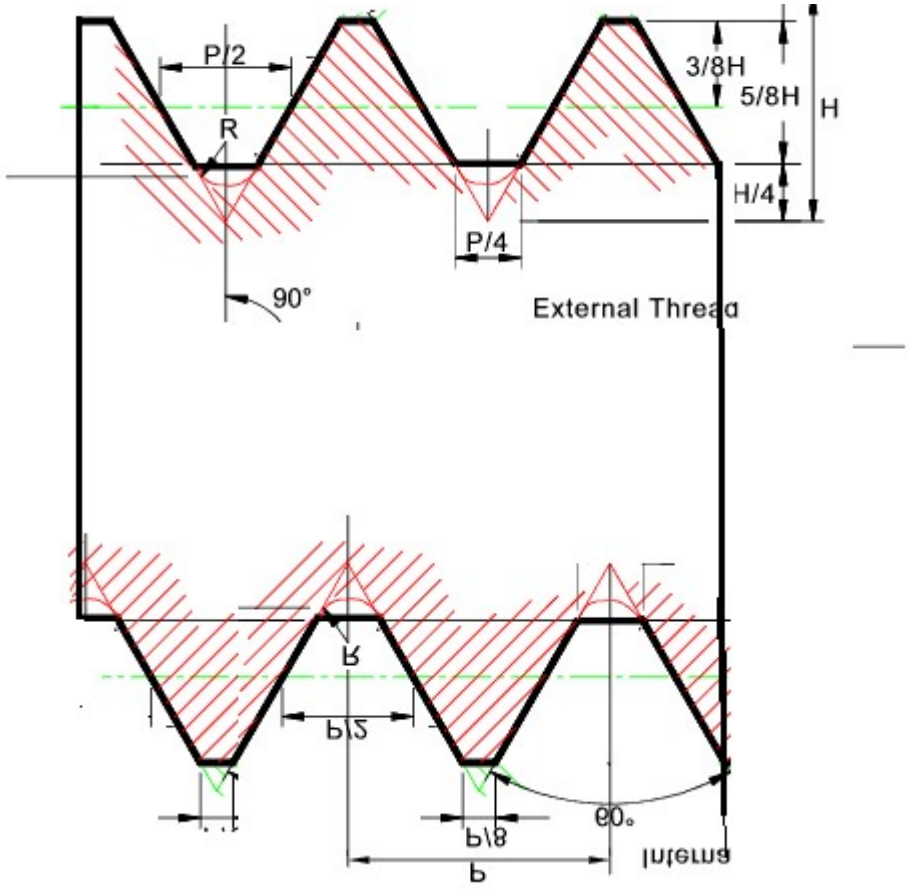
major

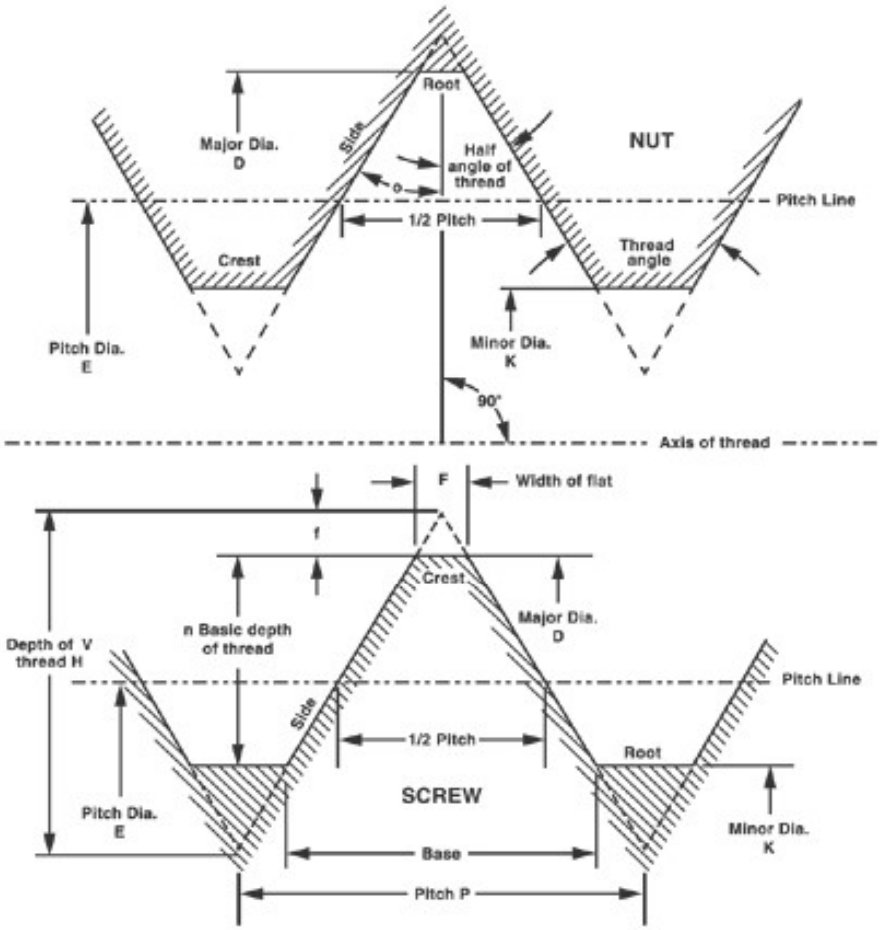
Type of threads

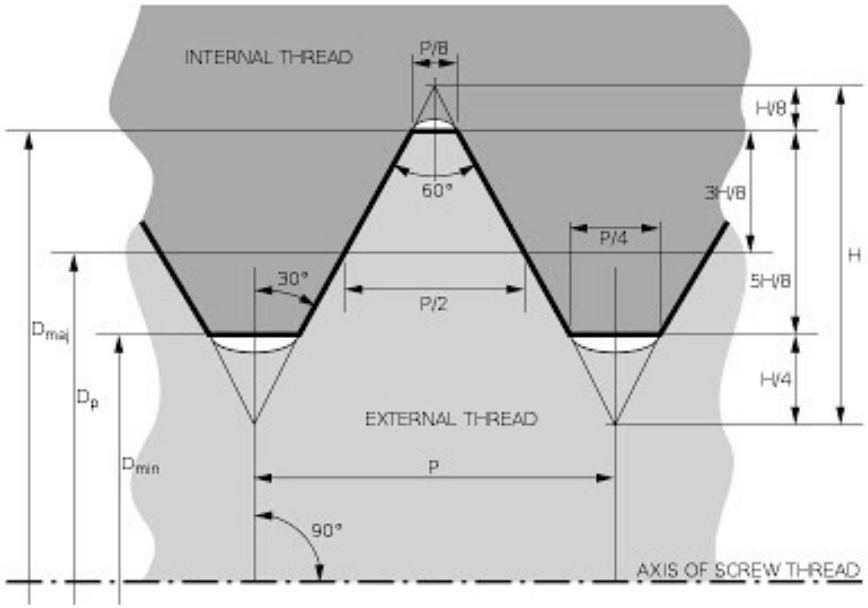
-Unified

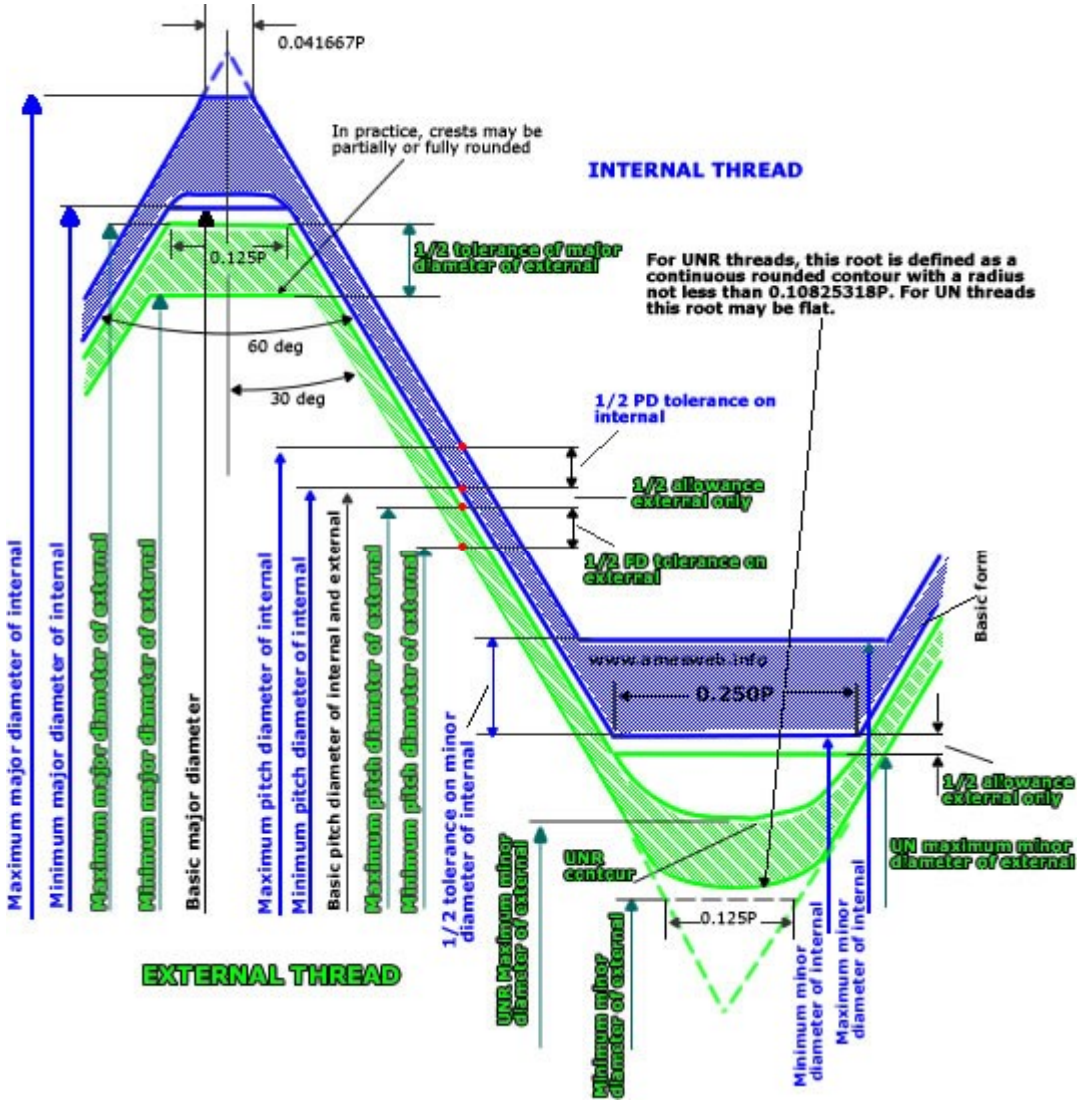
-Metric

- The basic profile of ISO Metric threads is built up from triangles of height H disposed symmetrically about a pitch line which becomes the ***pitch cylinder*** of diameter d_p
- when the profile is rotated about the axis to form the thread. The distance between adjacent triangles - the pitch - is $p = 2\,H/\sqrt{3}$.
- The tips of the triangles are truncated by H/8 to form the major diameter (size) d of the thread, and the bases are truncated by H/4 to form the minor diameter d_r. It follows that $d_r = d - 5\,H/4 = d - 1.08\,p$.


P/2
R
3/8H
5/8H
H
H/4
P/4
90°
External Thread


Root
Major Dia.
D
Side
Half
angle of
thread
NUT
Pitch Line
1/2 Pitch
Crest
Thread
angle
Pitch Dia.
E
Minor Dia.
K
90°
Axis of thread
F
Width of flat
f
Crest
n Basic depth
of thread
Major Dia.
D
Depth of V
thread H
Pitch Line
Side
1/2 Pitch
Root
SCREW
Pitch Dia.
E
Minor Dia.
K
Base
Pitch P


INTERNAL THREAD
P/8
H/8
3H/8
5H/8
H/4
H
60°
P/4
30°
P/2
D_{maj}
D_p
D_{min}
EXTERNAL THREAD
P
90°
AXIS OF SCREW THREAD


0.041667P
In practice, crests may be partially or fully rounded
INTERNAL THREAD
0.125P
1/2 tolerance of major diameter of external
For UNR threads, this root is defined as a continuous rounded contour with a radius not less than 0.10825318P. For UN threads this root may be flat.
60 deg
30 deg
1/2 PD tolerance on internal
1/2 allowance external only
1/2 PD tolerance on external
Basic form
www.ameweb.info
0.250P
1/2 allowance external only
UNR contour
UN maximum minor diameter of external
0.125P
Maximum major diameter of internal
Minimum major diameter of internal
Maximum major diameter of external
Minimum major diameter of external
Basic major diameter
Maximum pitch diameter of internal
Minimum pitch diameter of internal
Basic pitch diameter of internal and external
Maximum pitch diameter of external
Minimum pitch diameter of external
1/2 tolerance on minor diameter of internal
UNR Maximum minor diameter of external
Minimum minor diameter of external
Minimum minor diameter of internal
Maximum minor diameter of internal
EXTERNAL THREAD

Parameter/Condition	Symbol	Equation
Height of fundamental triangle	H	$\mathrm{H} = \frac{\sqrt{3}}{2}\mathrm{P}$
Thread basic pitch diameter	d_2, D_2	$\mathrm{d_2} = \mathrm{D_2} = \mathrm{d} - 2 \times \frac{3}{8}H = \mathrm{D} - 2 \times \frac{3}{8}H$
Thread basic minor diameter	d_1, D_1	$\mathrm{d_1} = \mathrm{D_1} = \mathrm{d} - 2 \times \frac{5}{8}H = \mathrm{D} - 2 \times \frac{5}{8}H$
External thread maximum major diameter	d_{max}	$d_{max} = d - es$
External thread minimum major diameter	d_{min}	$d_{min} = d_{max} - T_d$
External thread maximum pitch diameter	d_{2max}	$d_{2max} = d_2 - es$
External thread minimum pitch diameter	d_{2min}	$d_{2min} = d_{2max} - T_{d2}$

Standardization

- The *American National* (*Unified*) thread standard defines basic thread geometry for uniformity and interchangeability
- American National (Unified) thread
  - UN normal thread
  - UNR greater root radius for fatigue applications
- Metric thread
  - M series (normal thread)
  - MJ series (greater root radius)

UNJ and MJ threads, often referred to as “J” threads, are predominately used in the aerospace industry and other applications requiring high fatigue strength, including some automotive applications. The “UNJ” designation is used for inch screw threads and “MJ” for metric threads.

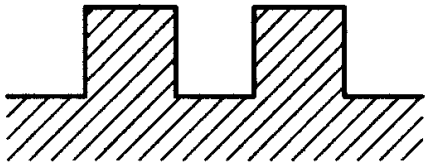
Standardization

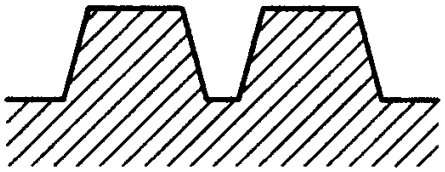
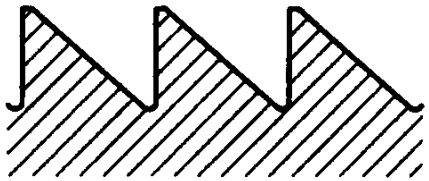
- Coarse series UNC
  - General assembly
  - Frequent disassembly
  - Not good for vibrations
  - The “normal” thread to specify
- Fine series UNF
  - Good for vibrations
  - Good for adjustments
  - Automotive and aircraft
- Extra Fine series UNEF
  - Good for shock and large vibrations
  - High grade alloy
  - Instrumentation
  - Aircraft

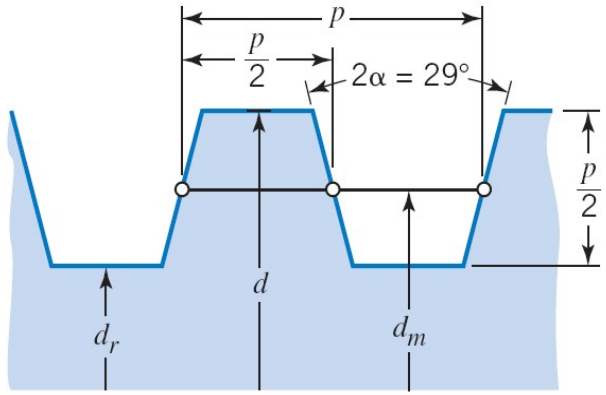
Different Types of Thread profiles:-

1. V Threads
2. Square Threads
3. ACME Threads
4. Buttress Threads

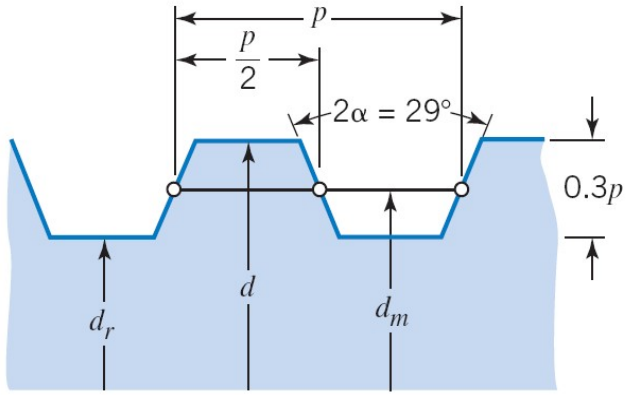
Thread profiles

		Uses
Unified screw thread		General use.
ISO metric screw thread		General use.
Square		Ideal thread for power transmission.

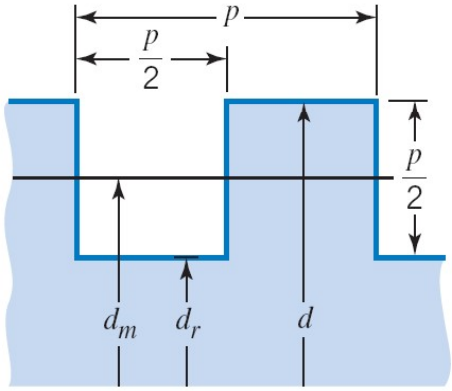
		Uses
ACME		Stronger than square thread.
Buttress		Designed to handle heavy forces in one direction. (Truck jack)



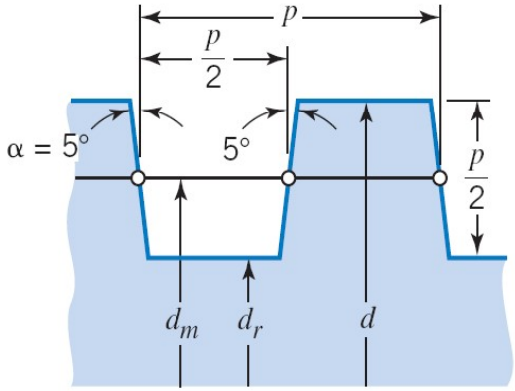
(a) Acme



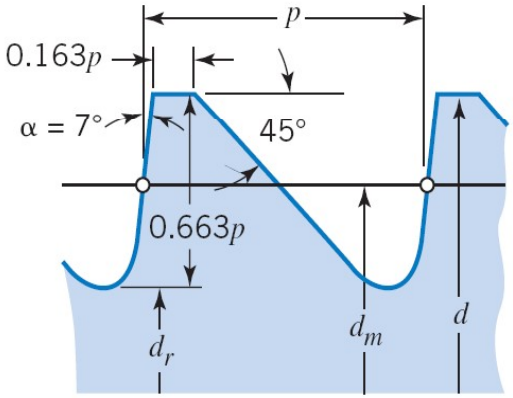
(b) Acme stub



(c) Square



(d) Modified square

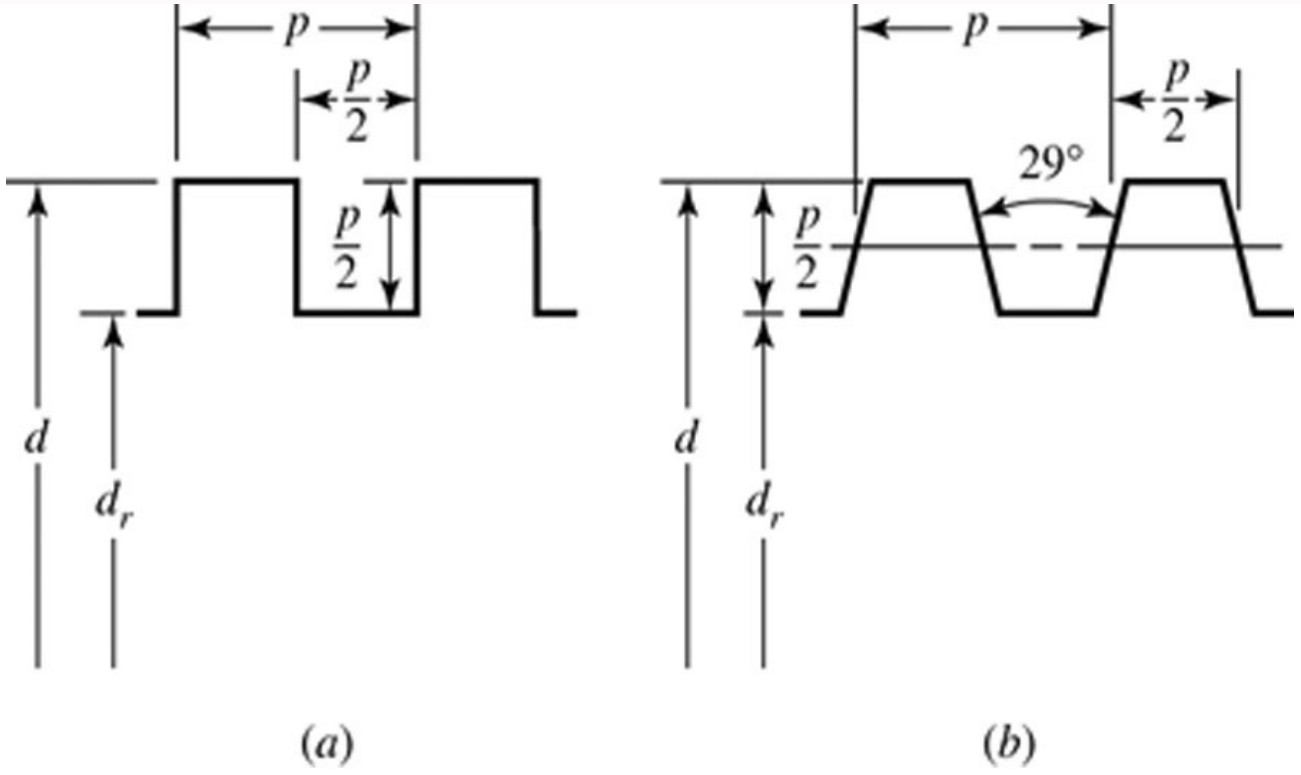


(e) Buttress

d_m is the mean diameter of the thread $(d + d_r)/2$.]

Thread Standards

3. Square (a) and The ACME Threads (b)-used mainly in power screws Table 8.3 gives preferred pitches for ACME threads



Square and Acme Threads

- Square and Acme threads are used when the threads are intended to transmit power

Fig. 8–3

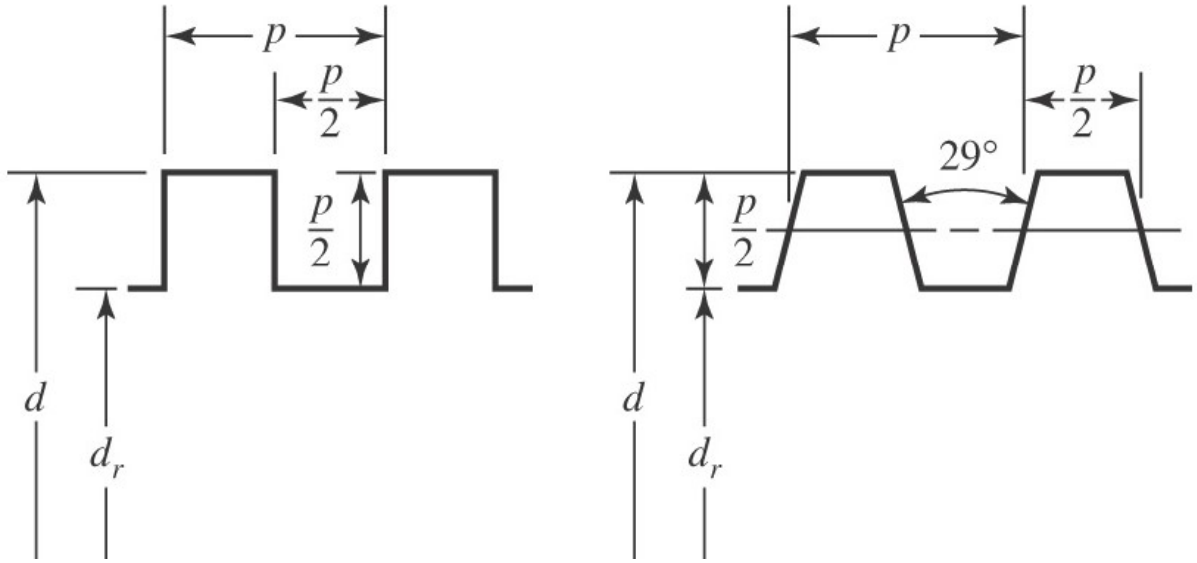


Table 8-3 Preferred Pitches for Acme Threads

d, in	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{2}$	3
p, in	$\frac{1}{16}$	$\frac{1}{14}$	$\frac{1}{12}$	$\frac{1}{10}$	$\frac{1}{8}$	$\frac{1}{6}$	$\frac{1}{6}$	$\frac{1}{5}$	$\frac{1}{5}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{2}$

Thread Standards

2) The American National (Unified) Thread standards is used mainly in the US: Table-8-2 (Size designation) use d

UN=regular thread, UNR=round root (use root radius)

Specifications: 5/8”-18 UN, UNC, UNF
UNR, UNRC, UNRF

5/8”=d 18 = N (thread size)

UN = Unified, F=fine, C=Coarse, R =Round Root

Thread Standards

1- Metric threads are specified by the letter M preceding the nominal major diameter in millimeters and the pitch in millimeters per thread.

EX: M10x12

M = Basic Metric, 10 = major diameter (mm); 2 = pitch (mm)

Diameters and Areas for Metric Threads

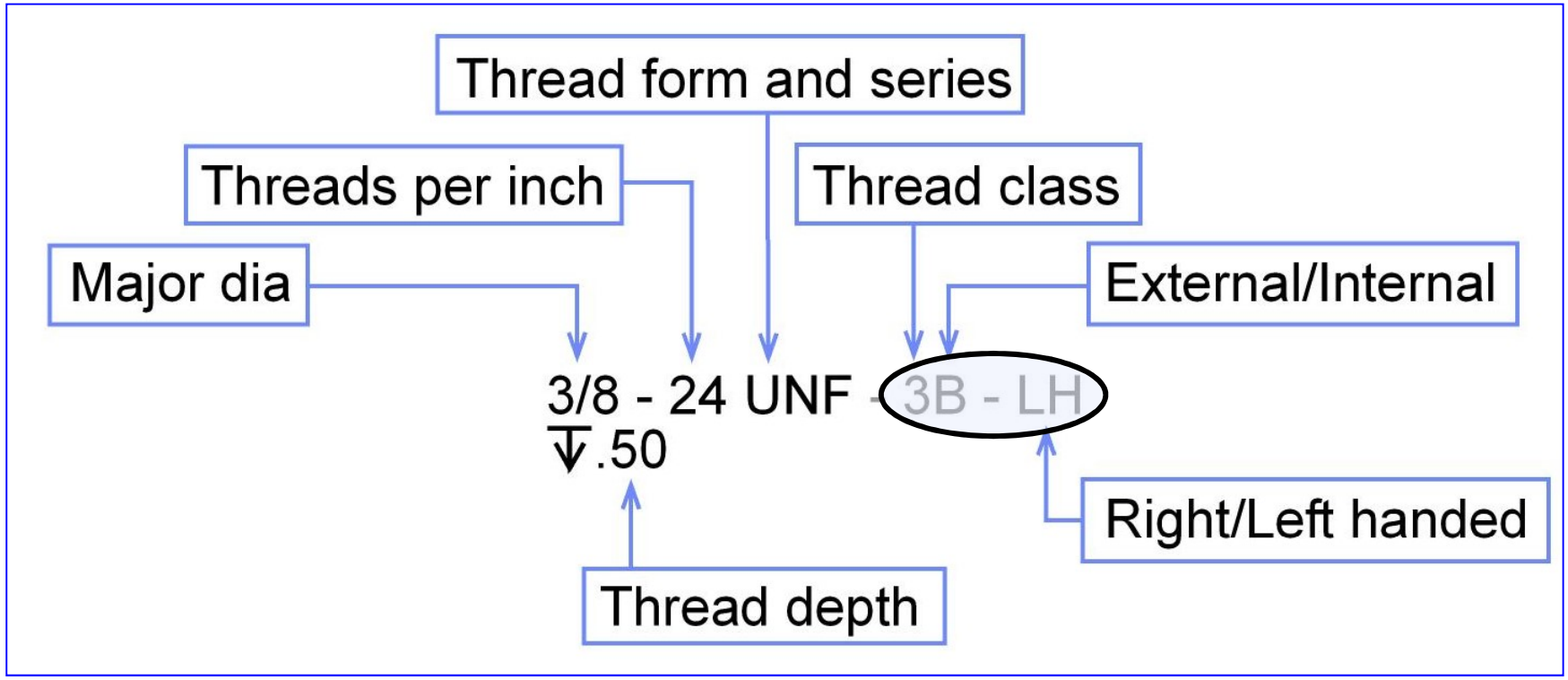
Table 8–1

Diameters and Areas of Coarse-Pitch and Fine-Pitch Metric Threads.*

Nominal Major Diameter d mm	Coarse-Pitch Series			Fine-Pitch Series		
	Pitch p mm	Tensile-Stress Area A_t mm^2	Minor-Diameter Area A_r mm^2	Pitch p mm	Tensile-Stress Area A_t mm^2	Minor-Diameter Area A_r mm^2
1.6	0.35	1.27	1.07			
2	0.40	2.07	1.79			
2.5	0.45	3.39	2.98			
3	0.5	5.03	4.47			
3.5	0.6	6.78	6.00			
4	0.7	8.78	7.75			
5	0.8	14.2	12.7			
6	1	20.1	17.9			
8	1.25	36.6	32.8	1	39.2	36.0
10	1.5	58.0	52.3	1.25	61.2	56.3
12	1.75	84.3	76.3	1.25	92.1	86.0
14	2	115	104	1.5	125	116
16	2	157	144	1.5	167	157
20	2.5	245	225	1.5	272	259
24	3	353	324	2	384	365
30	3.5	561	519	2	621	596
36	4	817	759	2	915	884
42	4.5	1120	1050	2	1260	1230
48	5	1470	1380	2	1670	1630
56	5.5	2030	1910	2	2300	2250
64	6	2680	2520	2	3030	2980

Unified Threads (inch)

- Thread class is assumed to be 2.
- Threads are assumed to be RH.



- Identify the different components of the following Unified National thread note.
- 1/4 – 20 UNC – 2A – RH

1/4	.25 inch Major DIA
20	20 threads per inch (P = 1/20 = .05)
UNC	Thread form & series – UN Coarse
2	Thread Class – Normal Production
A	External Threads
RH	Right Handed Threads

Diameters and Areas for Unified Screw Threads

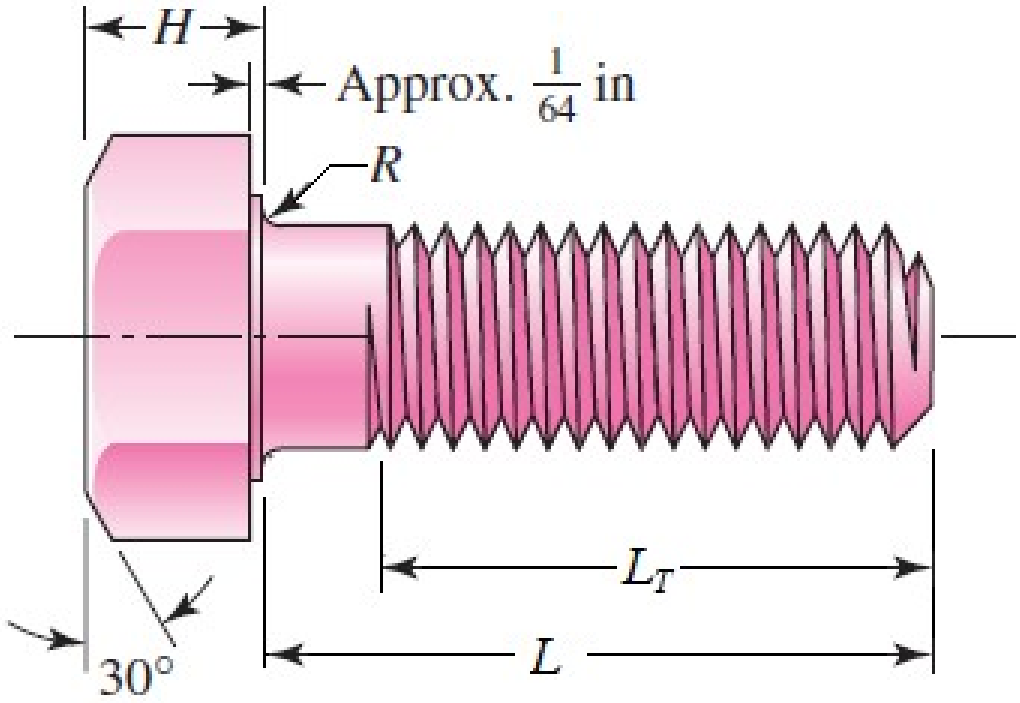
Table 8–2

Size Designation	Nominal Major Diameter in	Coarse Series—UNC			Fine Series—UNF		
		Threads per Inch N	Tensile-Stress Area A_t, in^2	Minor-Diameter Area A_r, in^2	Threads per Inch N	Tensile-Stress Area A_t, in^2	Minor-Diameter Area A_r, in^2
0	0.0600				80	0.001 80	0.001 51
1	0.0730	64	0.002 63	0.002 18	72	0.002 78	0.002 37
2	0.0860	56	0.003 70	0.003 10	64	0.003 94	0.003 39
3	0.0990	48	0.004 87	0.004 06	56	0.005 23	0.004 51
4	0.1120	40	0.006 04	0.004 96	48	0.006 61	0.005 66
5	0.1250	40	0.007 96	0.006 72	44	0.008 80	0.007 16
6	0.1380	32	0.009 09	0.007 45	40	0.010 15	0.008 74
8	0.1640	32	0.014 0	0.011 96	36	0.014 74	0.012 85
10	0.1900	24	0.017 5	0.014 50	32	0.020 0	0.017 5
12	0.2160	24	0.024 2	0.020 6	28	0.025 8	0.022 6
$\frac{1}{4}$	0.2500	20	0.031 8	0.026 9	28	0.036 4	0.032 6
$\frac{5}{16}$	0.3125	18	0.052 4	0.045 4	24	0.058 0	0.052 4
$\frac{3}{8}$	0.3750	16	0.077 5	0.067 8	24	0.087 8	0.080 9
$\frac{7}{16}$	0.4375	14	0.106 3	0.093 3	20	0.118 7	0.109 0
$\frac{1}{2}$	0.5000	13	0.141 9	0.125 7	20	0.159 9	0.148 6
$\frac{9}{16}$	0.5625	12	0.182	0.162	18	0.203	0.189
$\frac{5}{8}$	0.6250	11	0.226	0.202	18	0.256	0.240
$\frac{3}{4}$	0.7500	10	0.334	0.302	16	0.373	0.351
$\frac{7}{8}$	0.8750	9	0.462	0.419	14	0.509	0.480
1	1.0000	8	0.606	0.551	12	0.663	0.625
$1\frac{1}{4}$	1.2500	7	0.969	0.890	12	1.073	1.024
$1\frac{1}{2}$	1.5000	6	1.405	1.294	12	1.581	1.521

Threaded Lengths

English
$$L_T = \begin{cases} 2d + \frac{1}{4}\text{ in} & L \le 6\text{ in} \\ 2d + \frac{1}{2}\text{ in} & L > 6\text{ in} \end{cases} \qquad (8\text{–}13)$$

Metric
$$L_T = \begin{cases} 2d + 6 & L \le 125 \quad d \le 48 \\ 2d + 12 & 125 < L \le 200 \\ 2d + 25 & L > 200 \end{cases} \qquad (8\text{–}14)$$



Head Type of Bolts

- Hexagon head bolt
  - Usually uses nut
  - Heavy duty
- Hexagon head cap screw
  - Thinner head
  - Often used as screw (in threaded hole, without nut)
- Socket head cap screw
  - Usually more precision applications
  - Access from the top
- Machine screws
  - Usually smaller sizes
  - Slot or philips head common
  - Threaded all the way

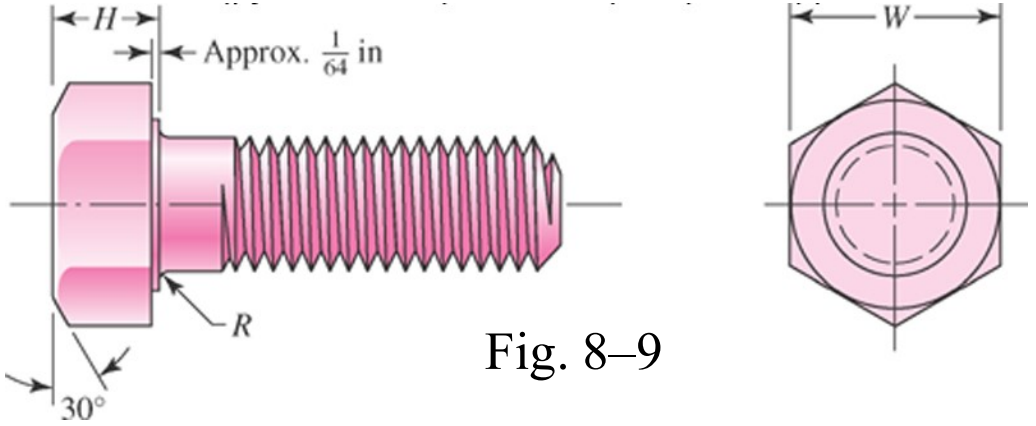


Fig. 8–9

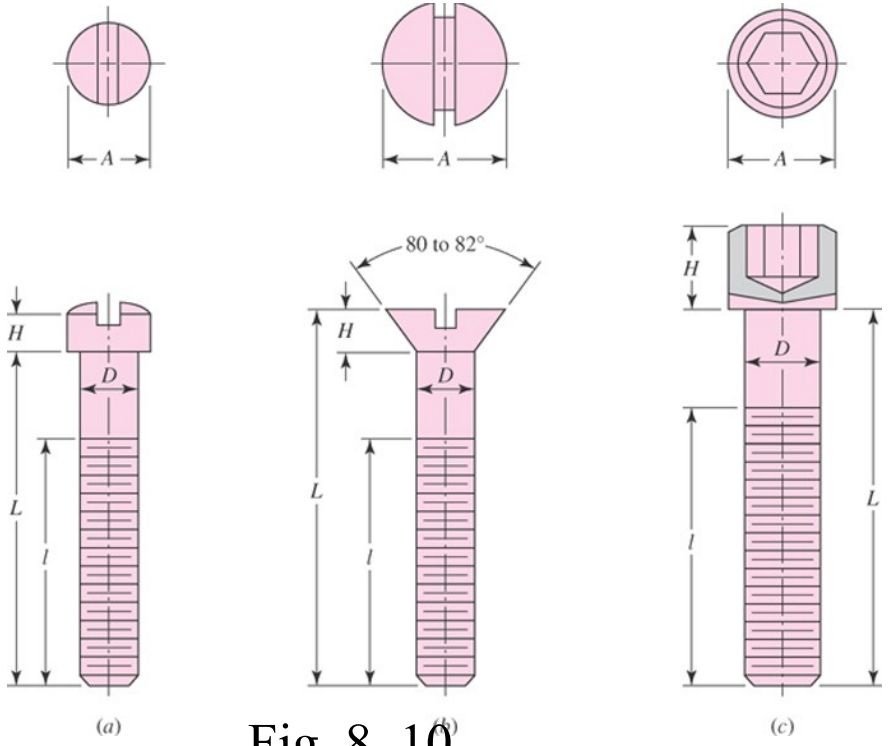
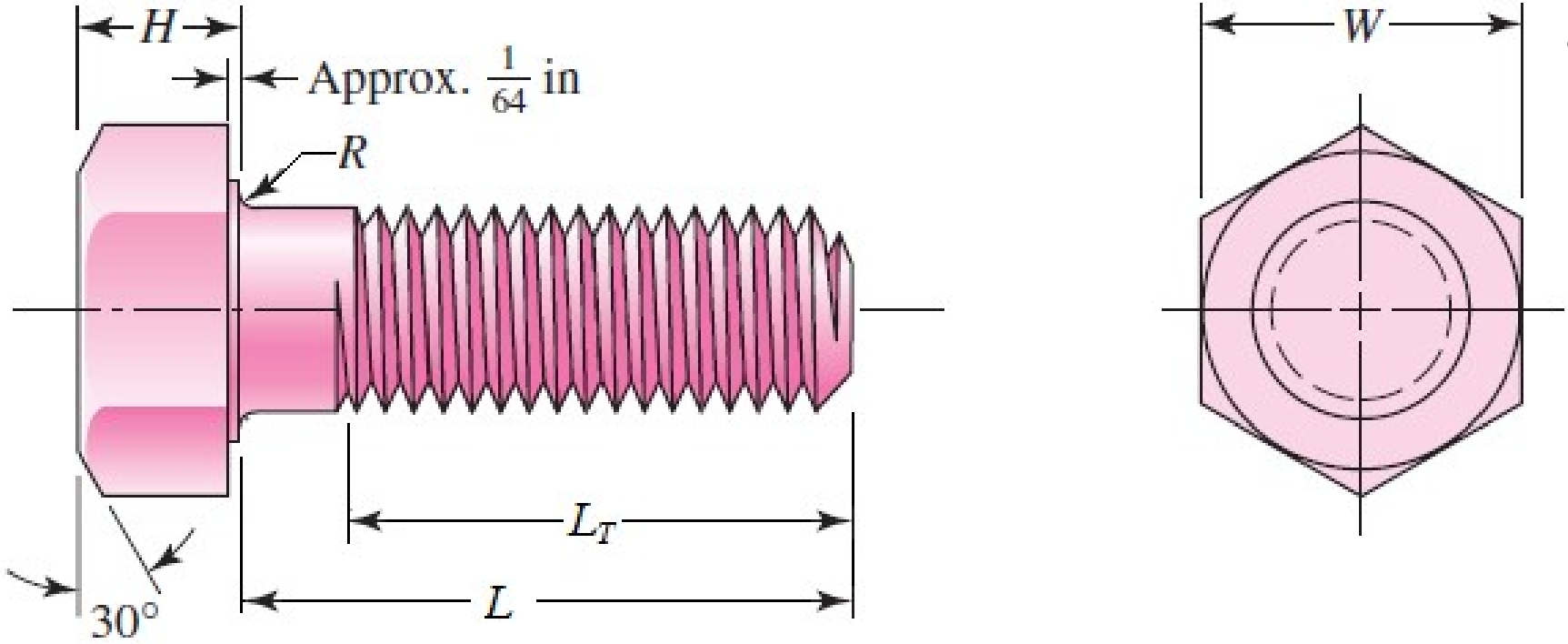
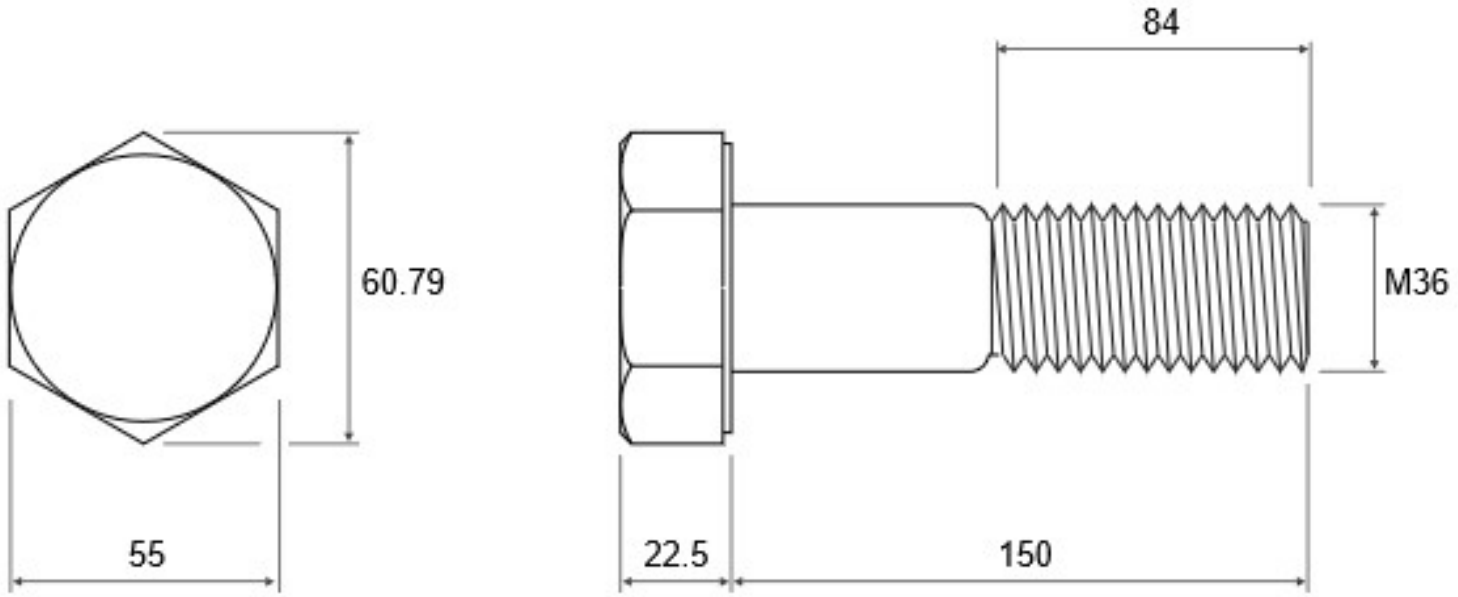


Fig. 8–10

Hexagon-Head Bolt

- Hexagon-head bolts are one of the most common for engineering applications
- Standard dimensions are included in Table A–29
- *W* is usually about 1.5 times nominal diameter





M 36

Machine Screws

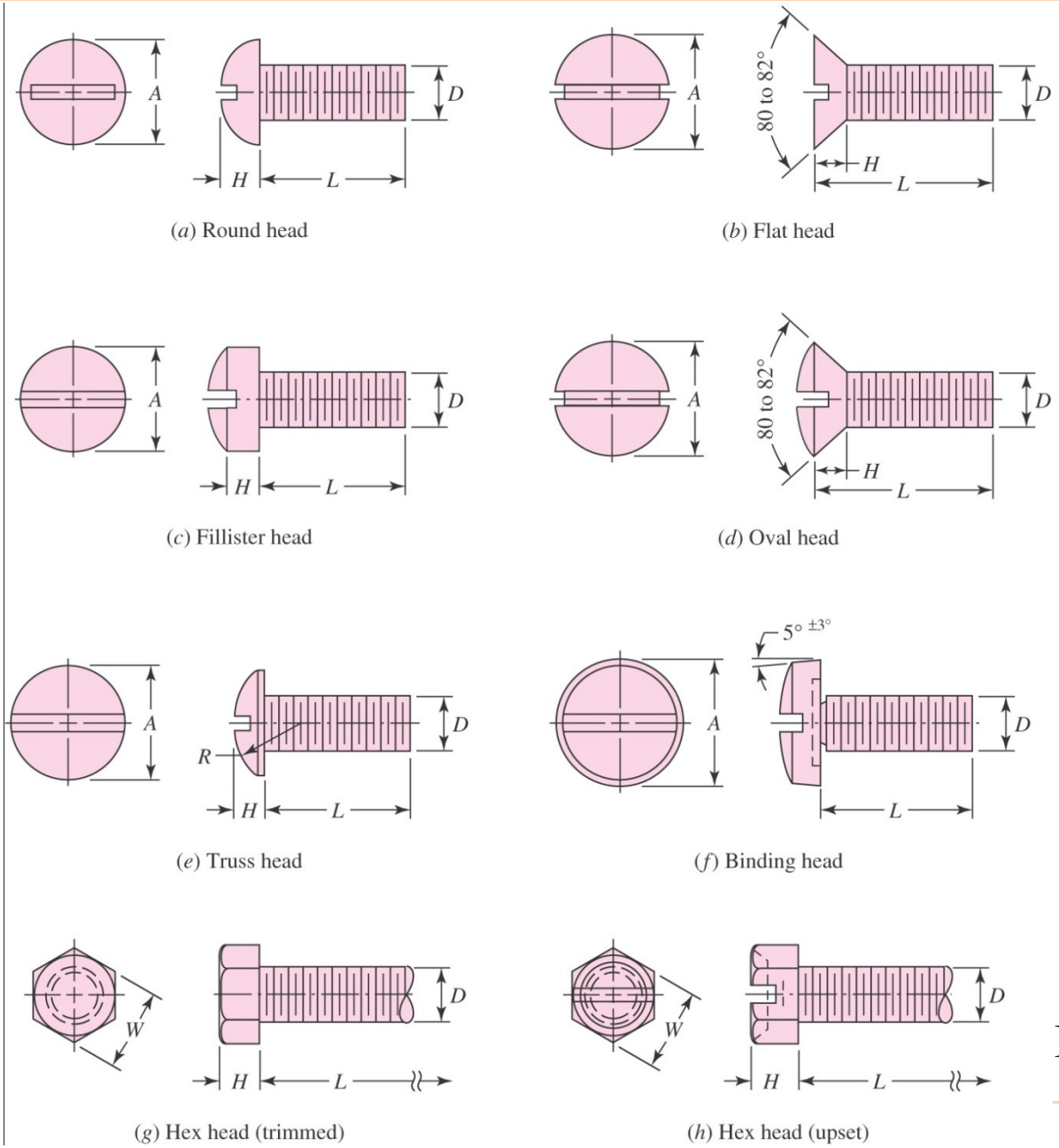
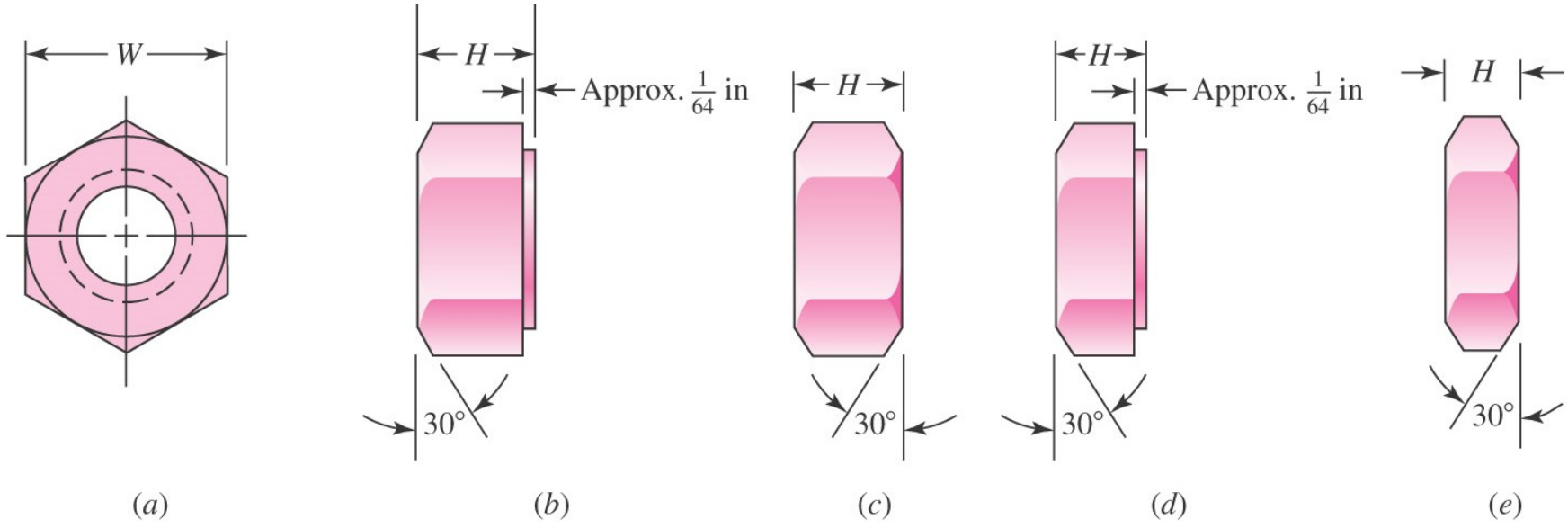


Fig. 8–11

Nuts

- See Appendix A–31 for typical specifications
- First three threads of nut carry majority of load
- Localized plastic strain in the first thread is likely, so nuts should not be re-used in critical applications.



End view | Washer-faced, regular | Chamfered both sides, regular | Washer-faced, jam nut | Chamfered both sides, jam nut

Prob.8–1 A power screw is 25 mm in diameter and has a thread pitch of 5 mm.
(*a) Find the thread depth, the thread width, the mean and root diameters, and the lead, provided* square threads are used.
(*b) Repeat part (a) for Acme threads*

the thread depth=P/2=5/2=2.5 mm

mean diameter d_m *= 25 - 1.25 - 1.25 = 22.5 mm*

root diameter d_r *= 25 - 5 = 20 mm*

Lead=l=P=5 mm

Thread depth =P/2= 2.5 mm
Width P/2= 2.5 mm this is at pitch line

Same dm and dr as in the square screw