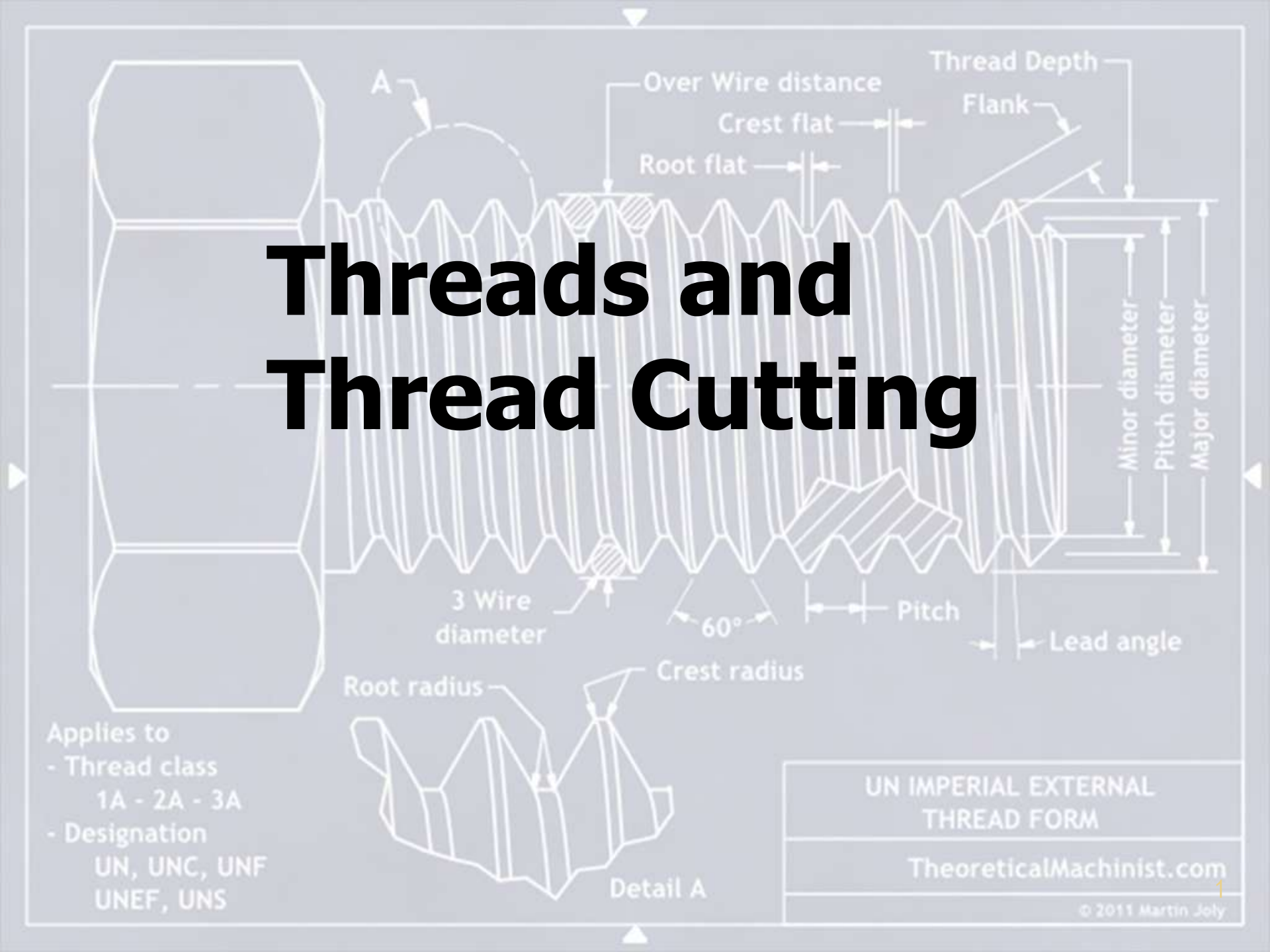
Threads and Thread Cutting



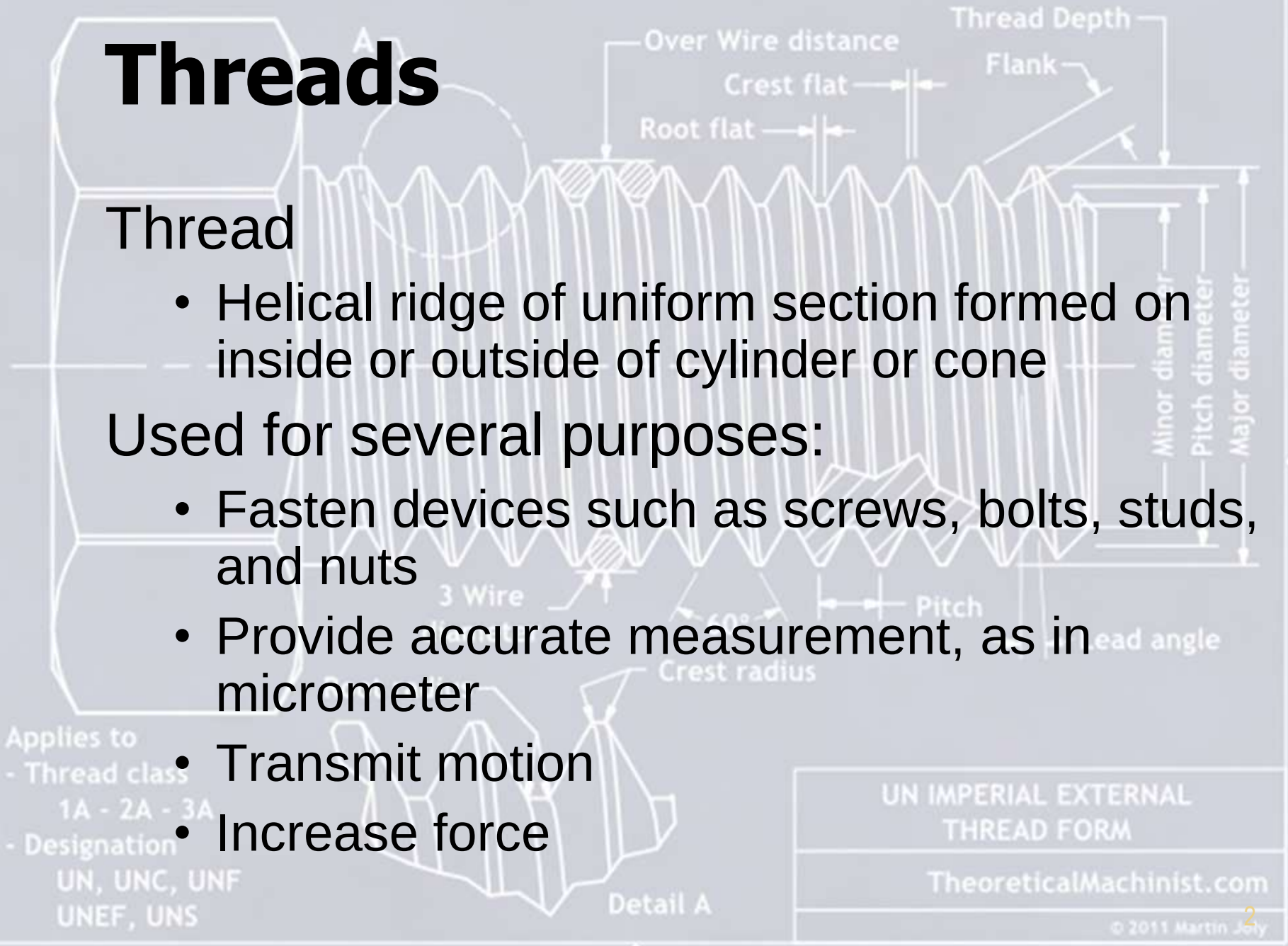
Threads

Thread

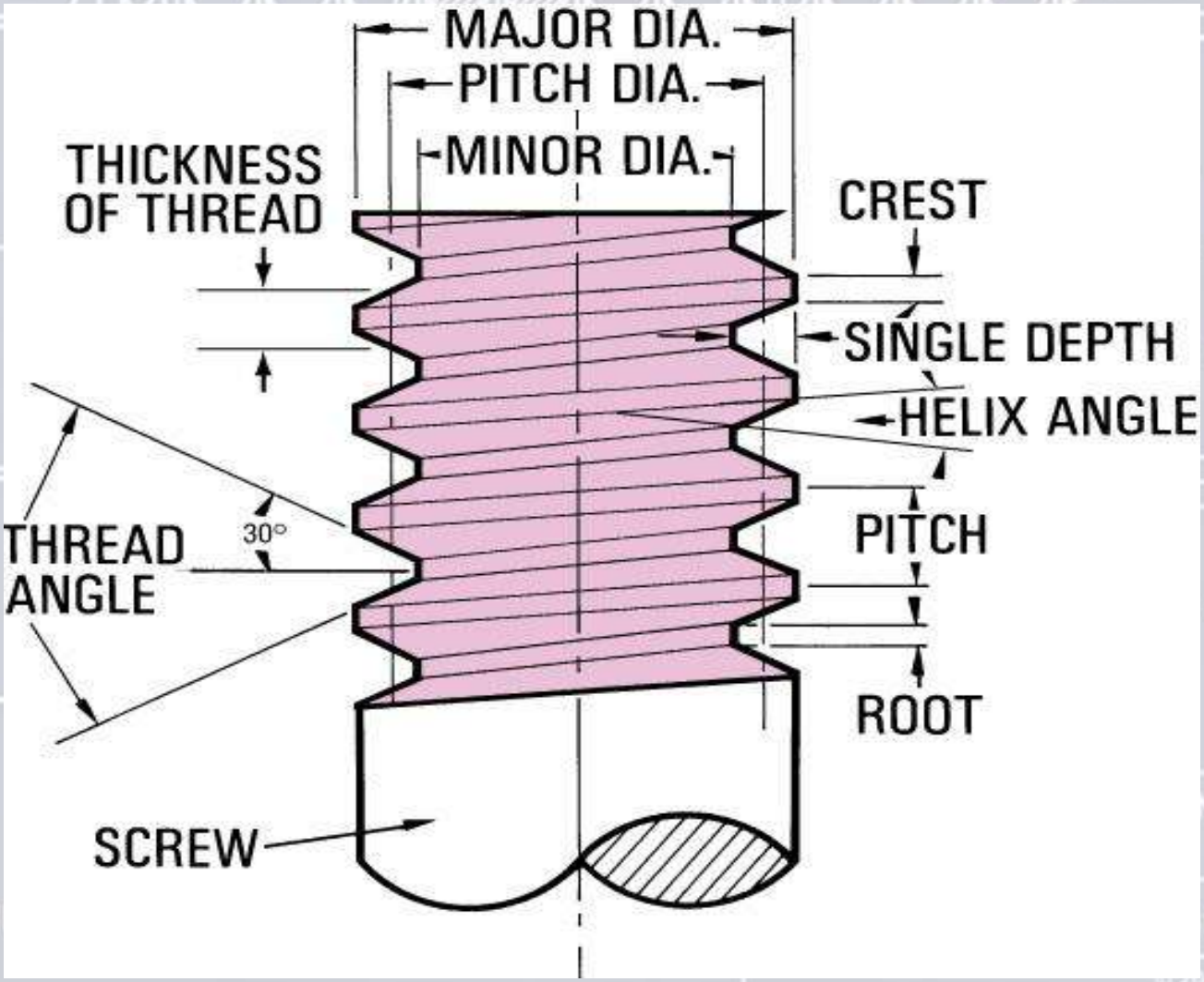
- Helical ridge of uniform section formed on inside or outside of cylinder or cone

Used for several purposes:

- Fasten devices such as screws, bolts, studs, and nuts
- Provide accurate measurement, as in micrometer
- Transmit motion
- Increase force



Thread Terminology



Thread Terminology

Screw thread

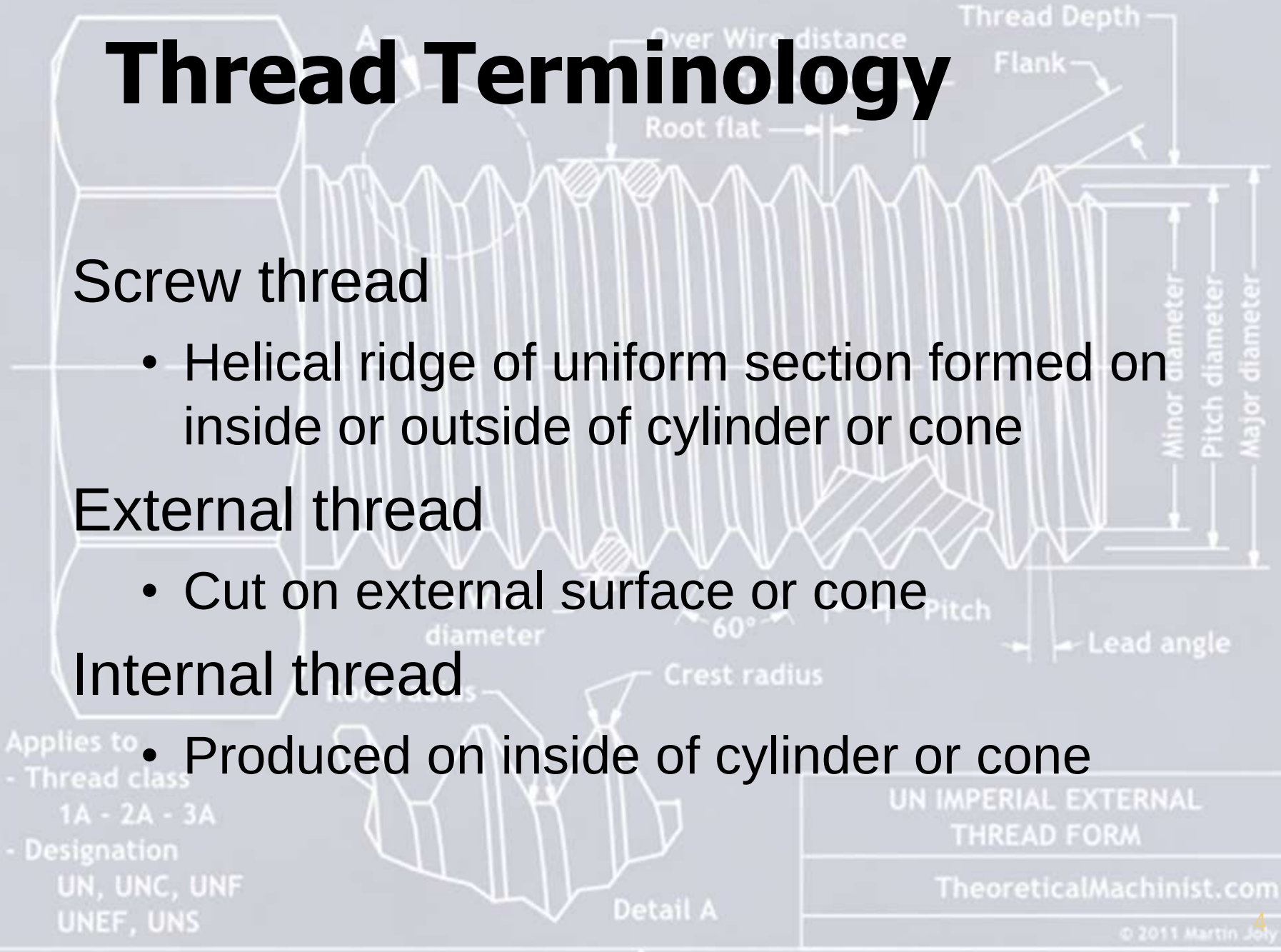
- Helical ridge of uniform section formed on inside or outside of cylinder or cone

External thread

- Cut on external surface or cone

Internal thread

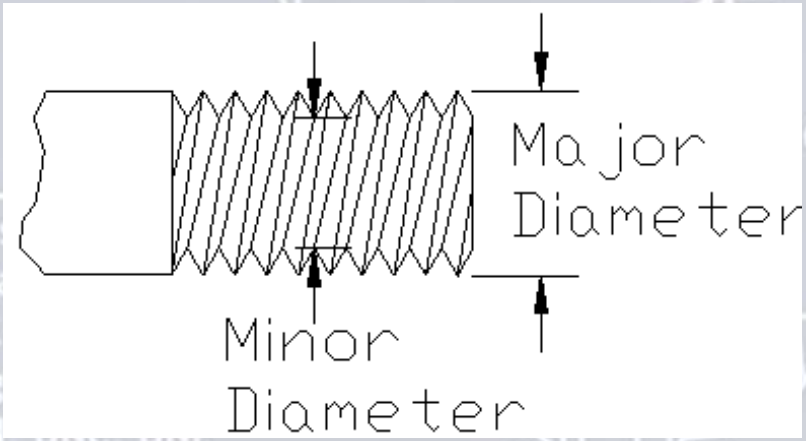
- Produced on inside of cylinder or cone

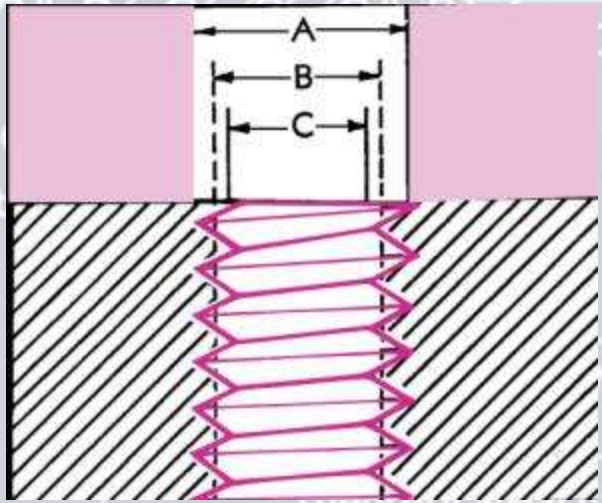


Thread Terminology

Major Diameter

Commonly known as the outside diameter . On a screw thread, the major diameter is the largest diameter of the thread on the screw or nut.

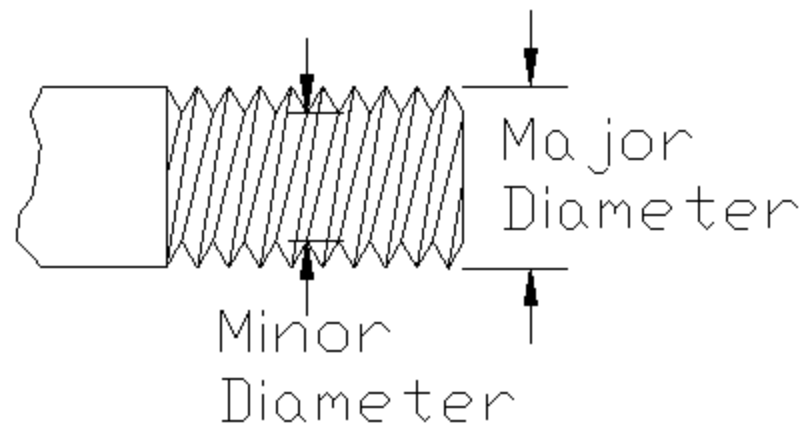


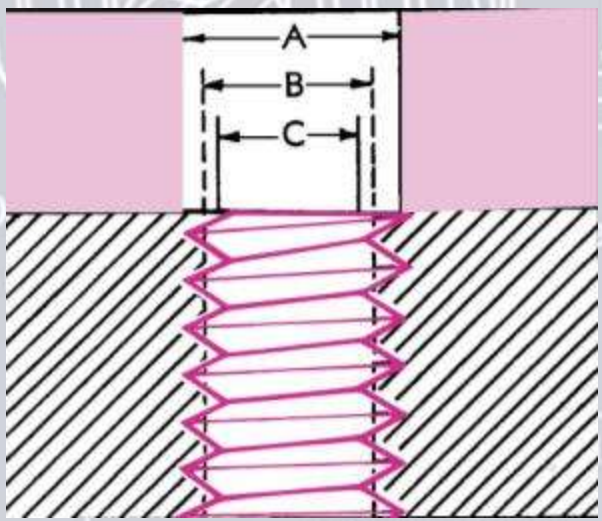


Thread Terminology

Minor Diameter

Called the root diameter, the minor diameter is the smallest diameter of the thread on the screw or nut.

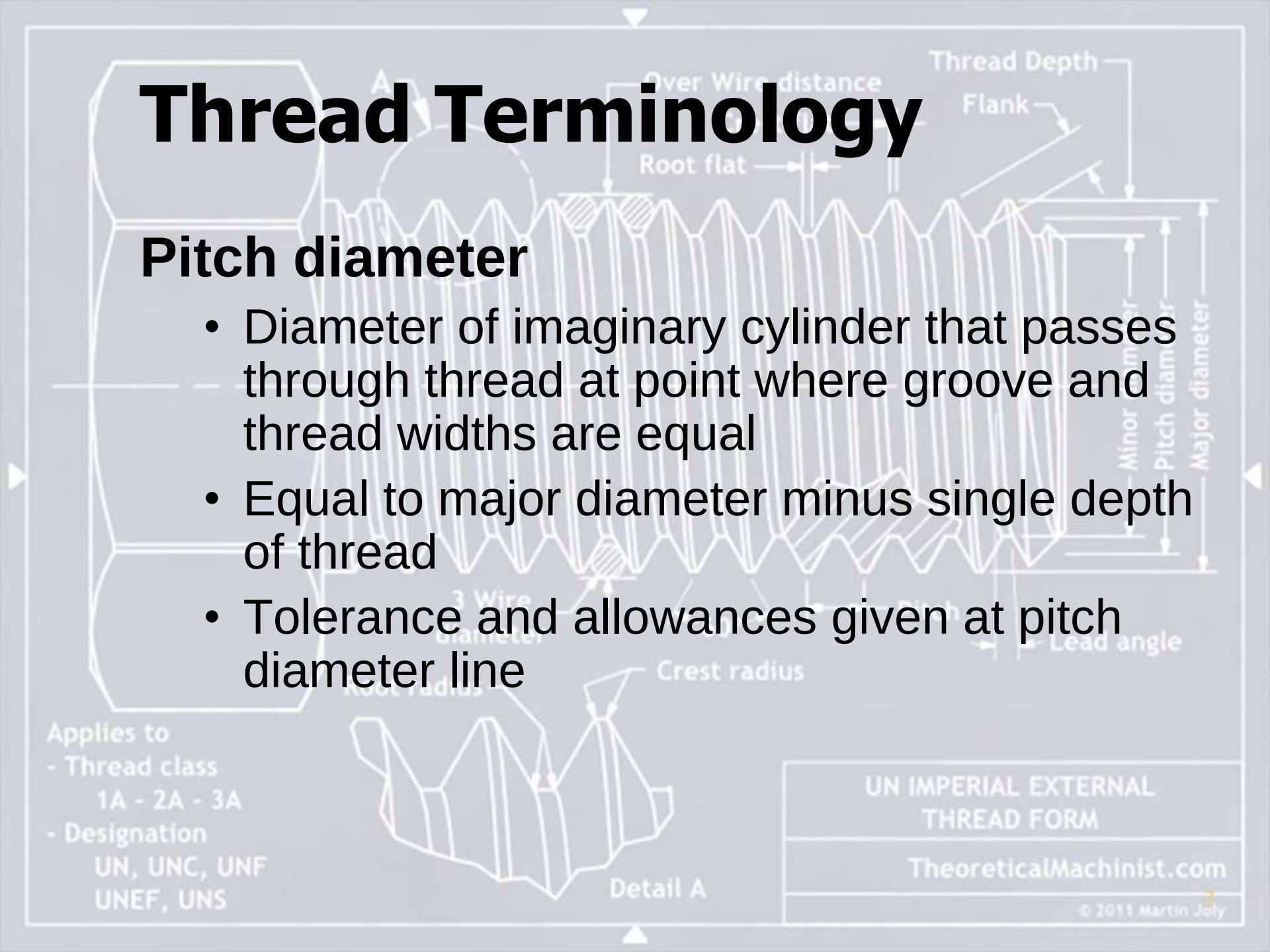




Thread Terminology

Pitch diameter

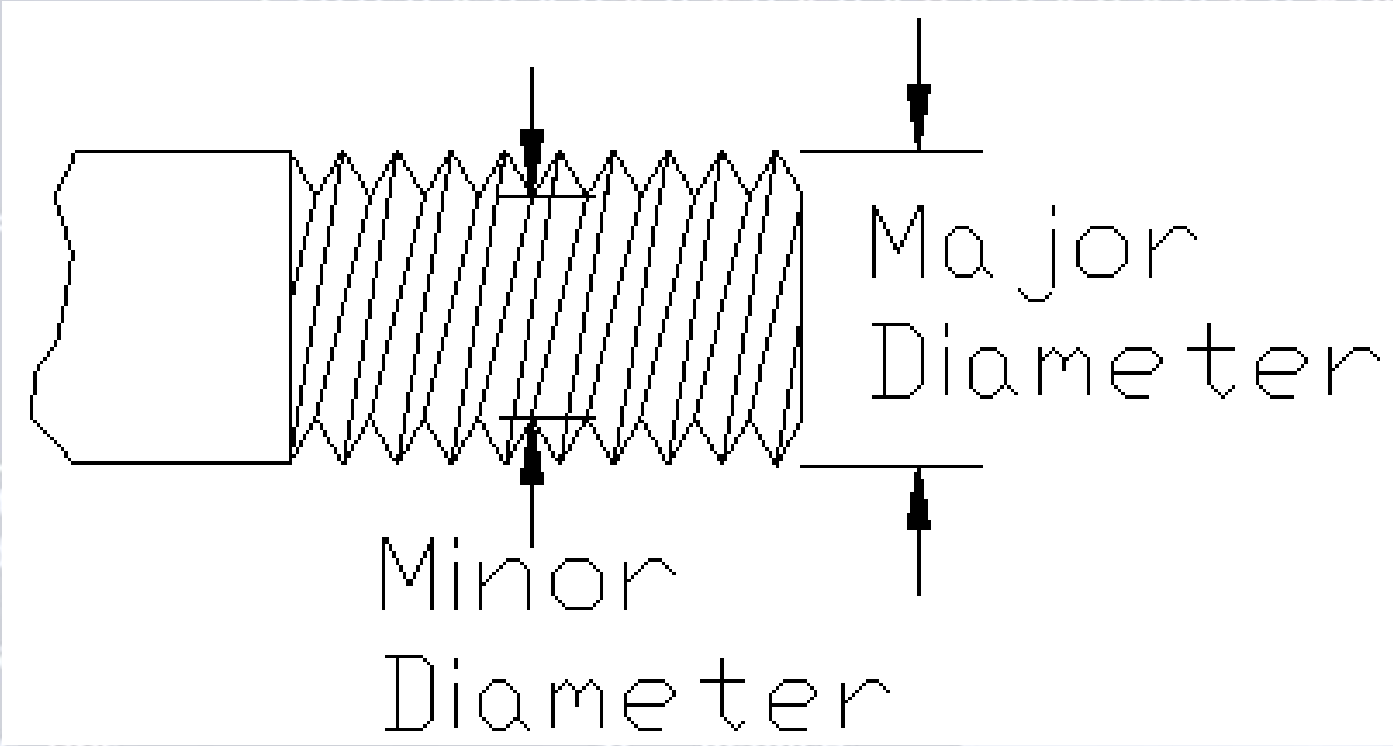
- Diameter of imaginary cylinder that passes through thread at point where groove and thread widths are equal
- Equal to major diameter minus single depth of thread
- Tolerance and allowances given at pitch diameter line



Thread Terminology

Number of Threads

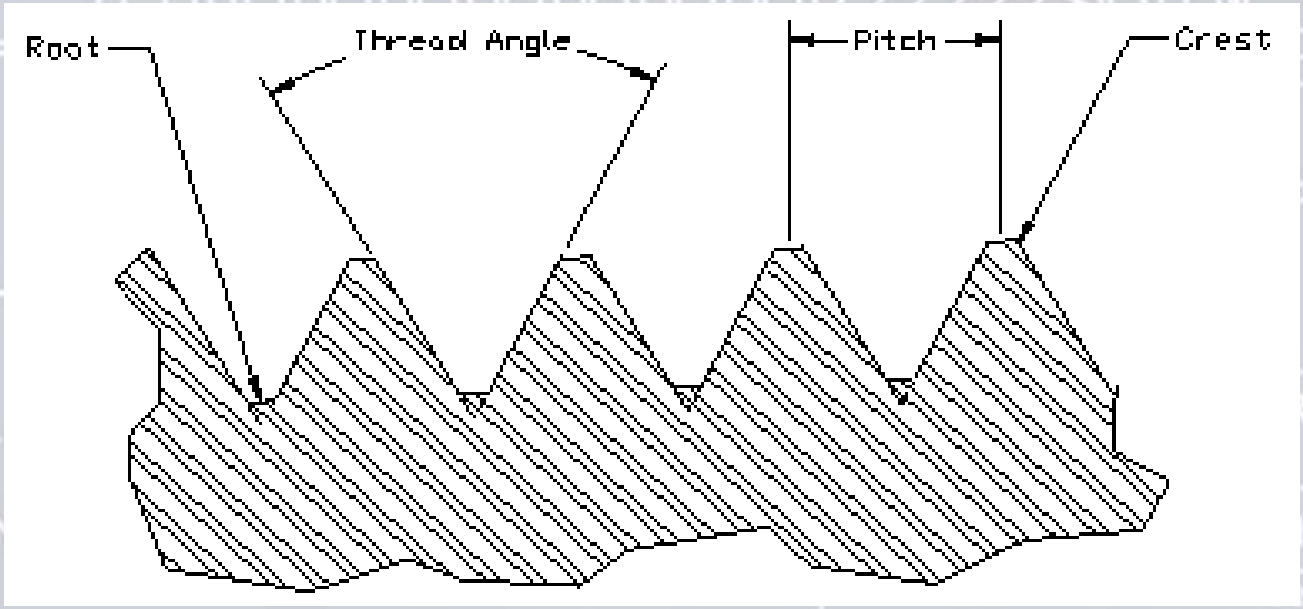
The number of threads per inch.



Thread Terminology

Pitch

The distance from a given point on one thread to a corresponding point on the very next thread

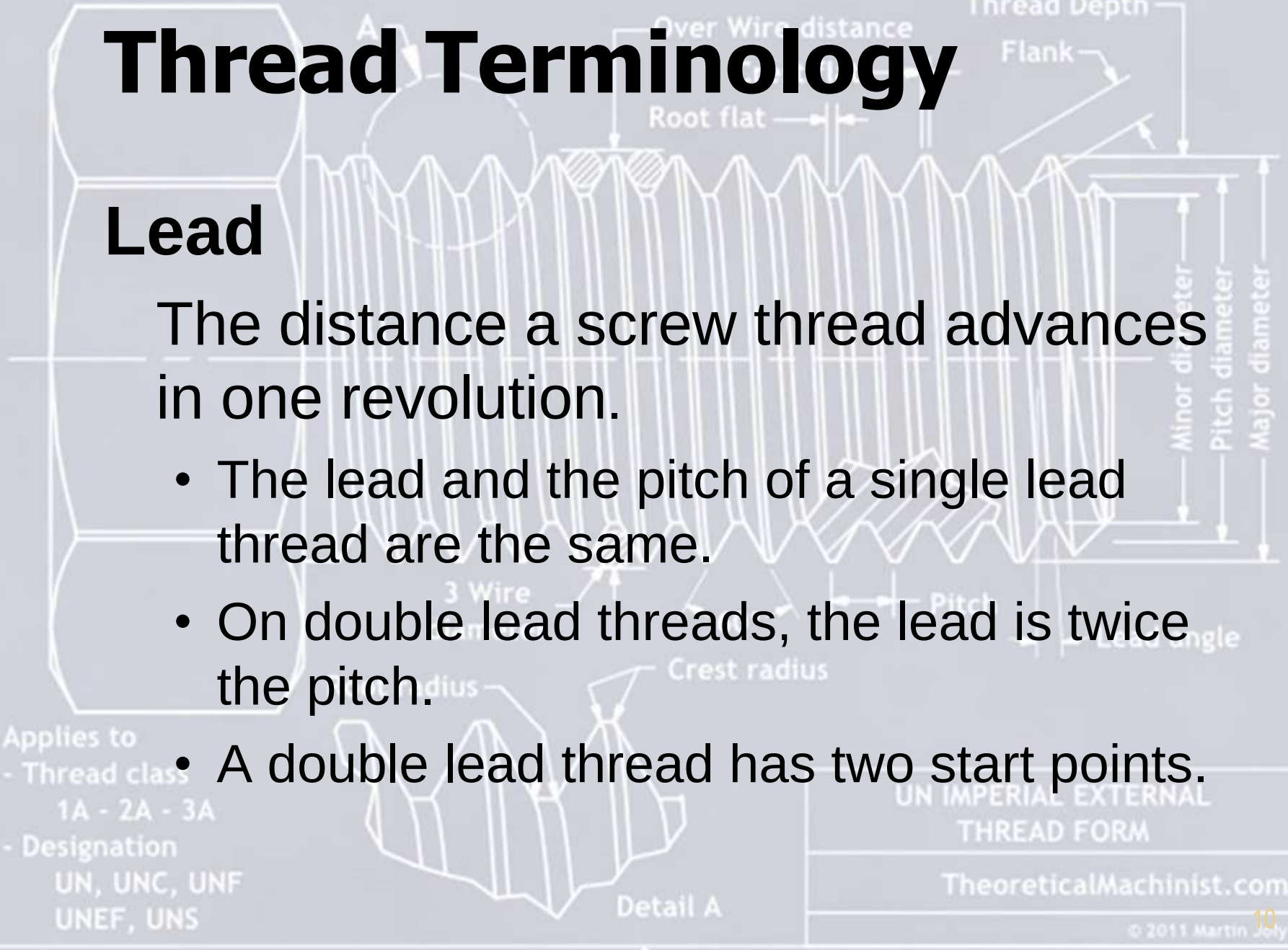


Thread Terminology

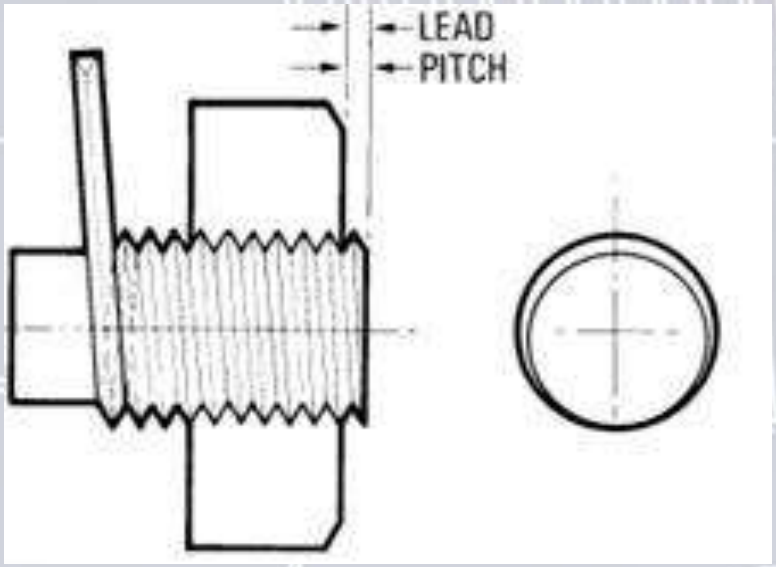
Lead

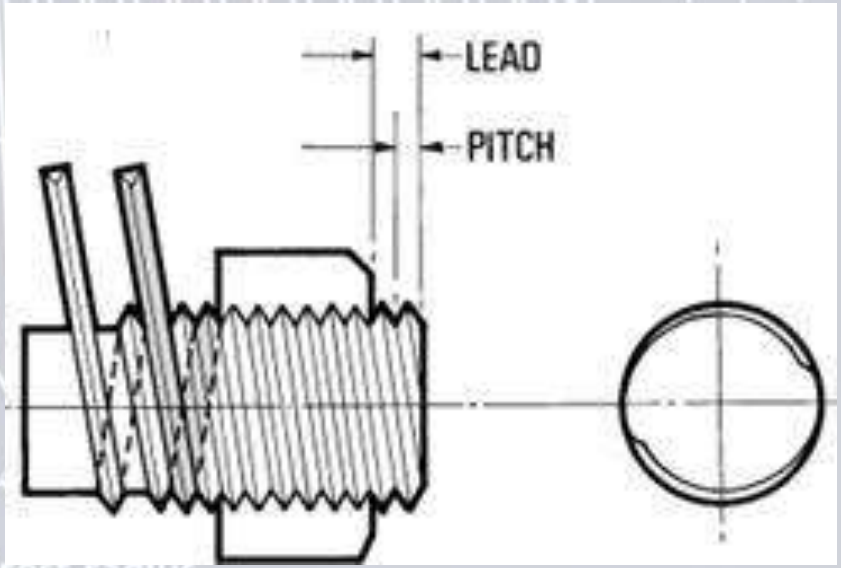
The distance a screw thread advances in one revolution.

- The lead and the pitch of a single lead thread are the same.
- On double lead threads, the lead is twice the pitch.
- A double lead thread has two start points.



Thread Terminology





Single Lead

Double Lead

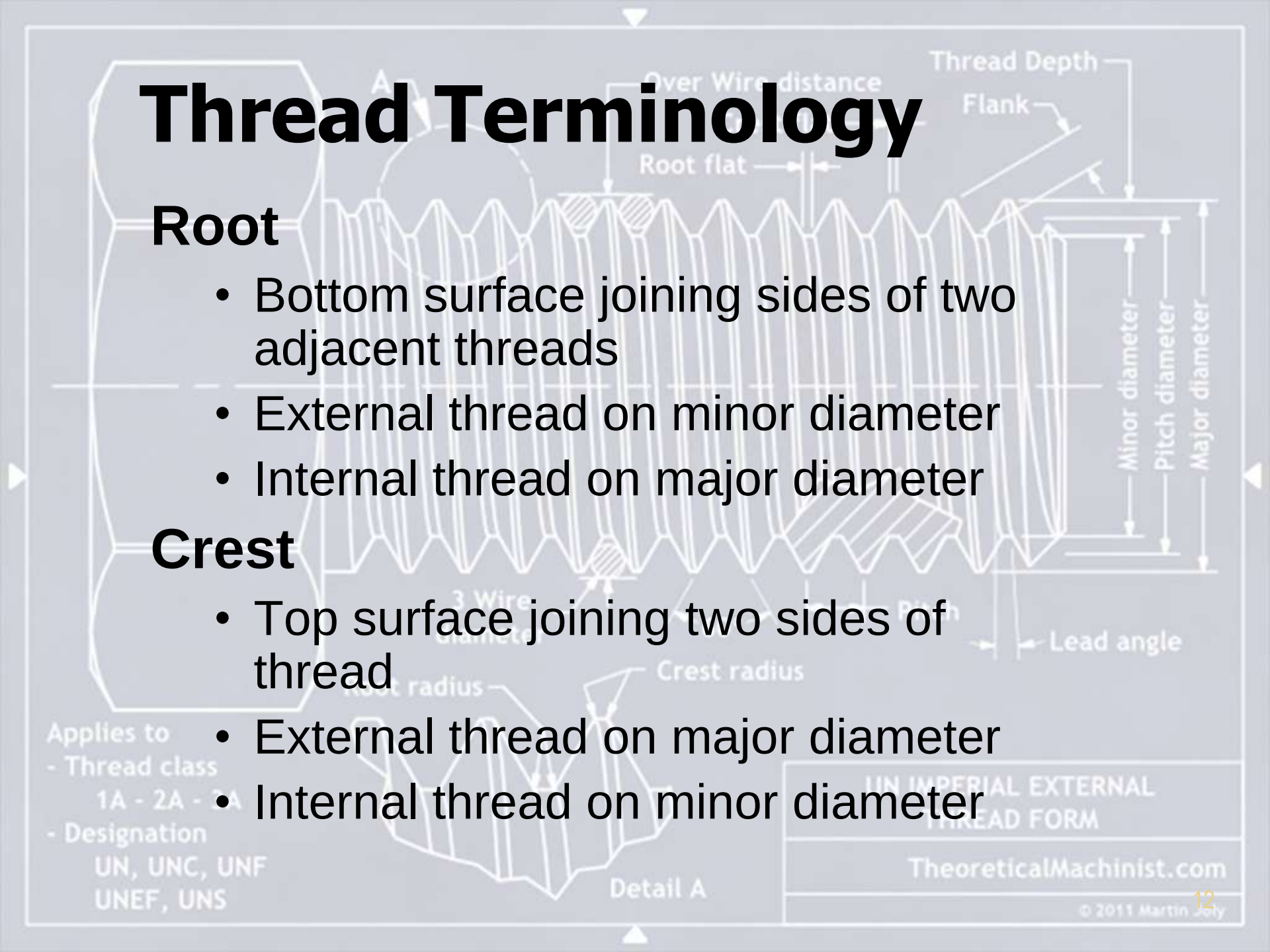
Thread Terminology

Root

- Bottom surface joining sides of two adjacent threads
- External thread on minor diameter
- Internal thread on major diameter

Crest

- Top surface joining two sides of thread
- External thread on major diameter
- Internal thread on minor diameter



Thread Terminology

Flank

- Thread surface that connects crest with root

Depth of thread

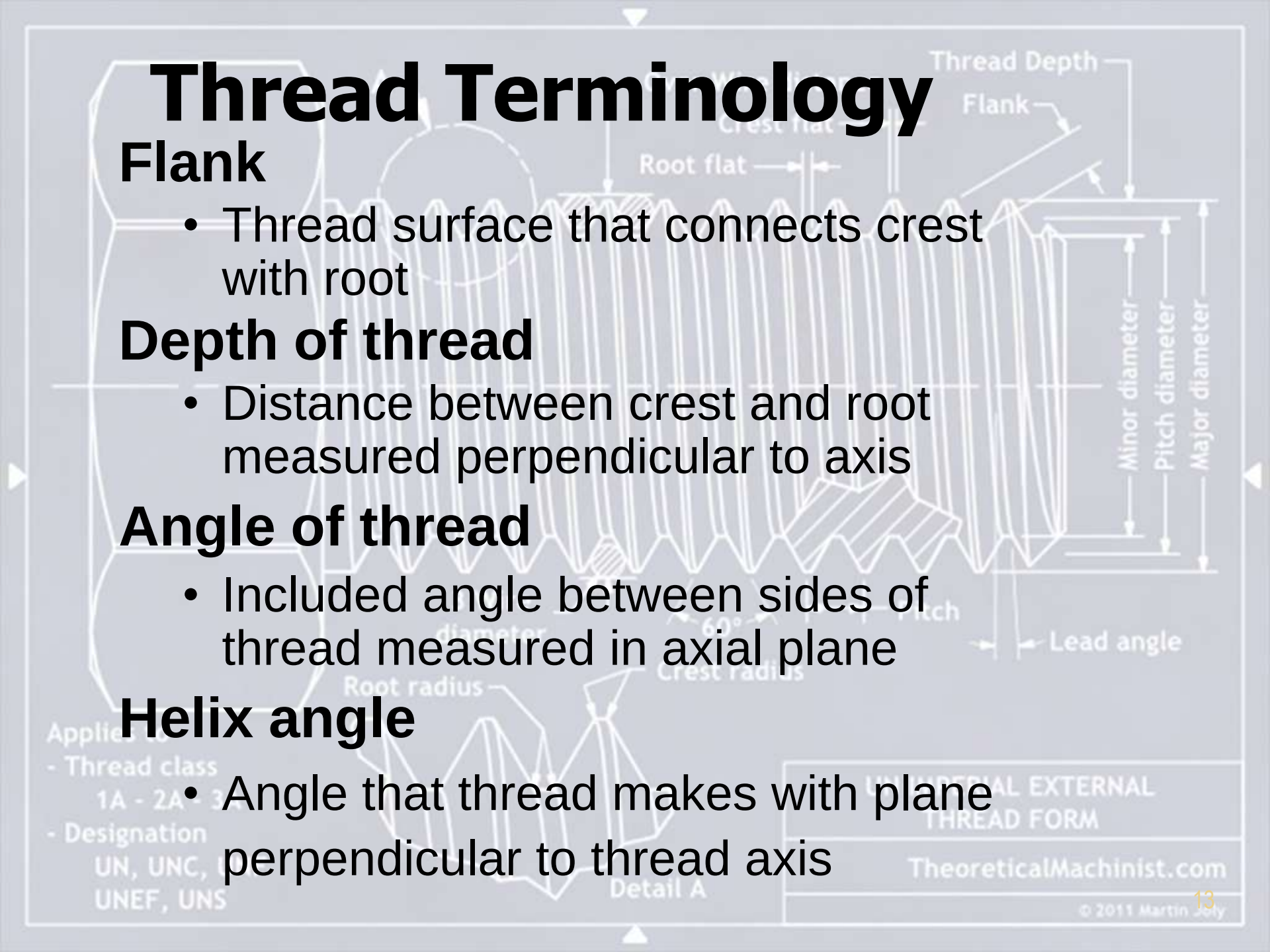
- Distance between crest and root measured perpendicular to axis

Angle of thread

- Included angle between sides of thread measured in axial plane

Helix angle

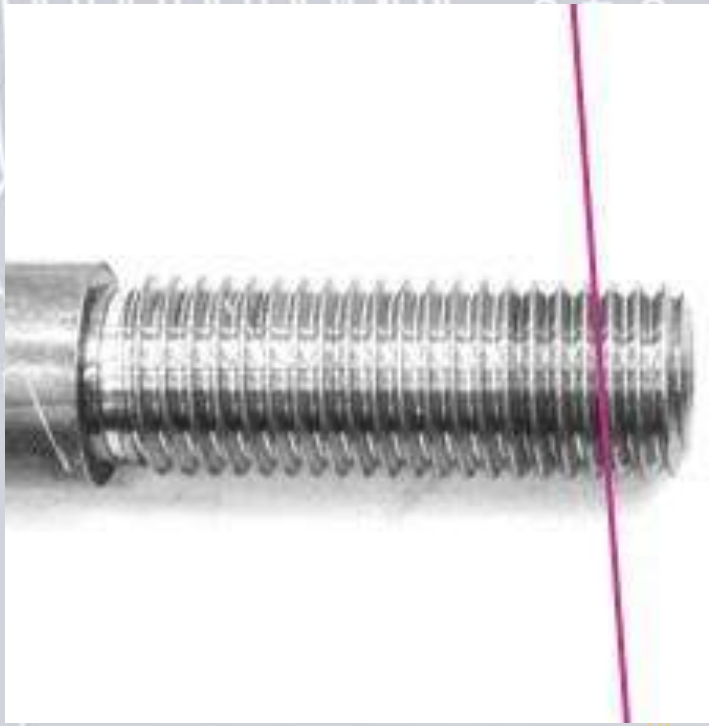
- Angle that thread makes with plane perpendicular to thread axis



Thread Terminology

Right-hand thread

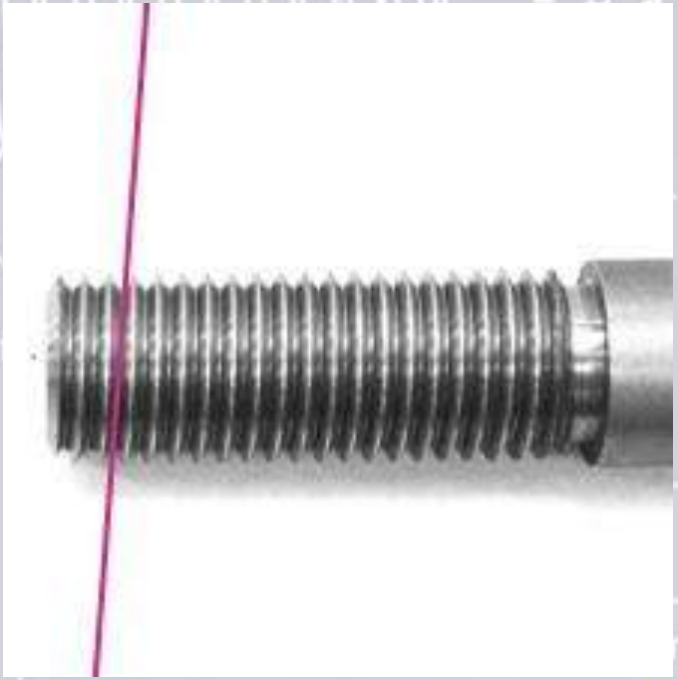
- Helical ridge of uniform cross section onto which nut is threaded in clockwise direction
- When cut on lathe the tool is advanced from right to left



Thread Terminology

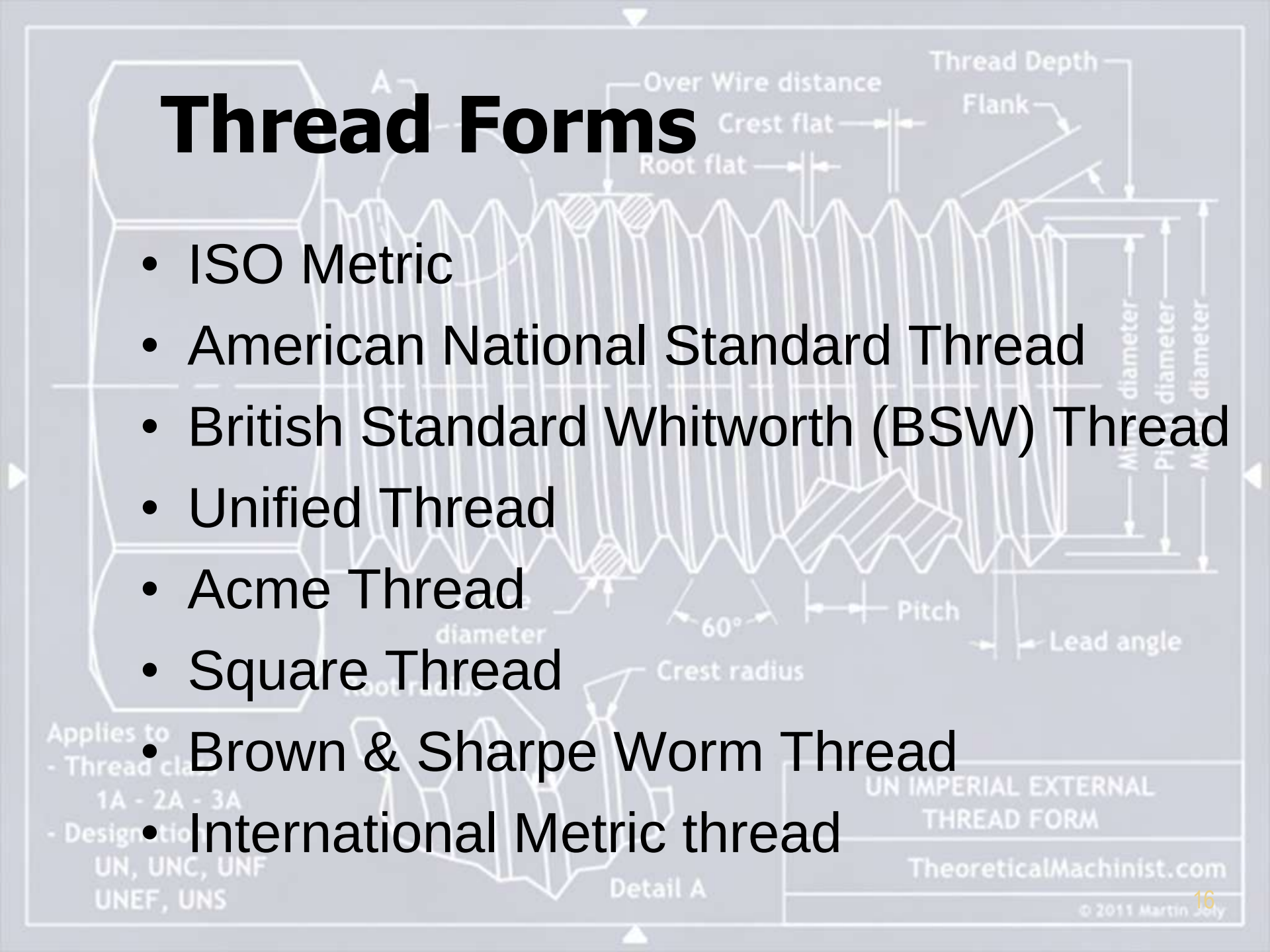
Left-hand thread

- Helical ridge of uniform cross section onto which nut is threaded in counterclockwise direction
- When cut on lathe the tool is advanced from left to right



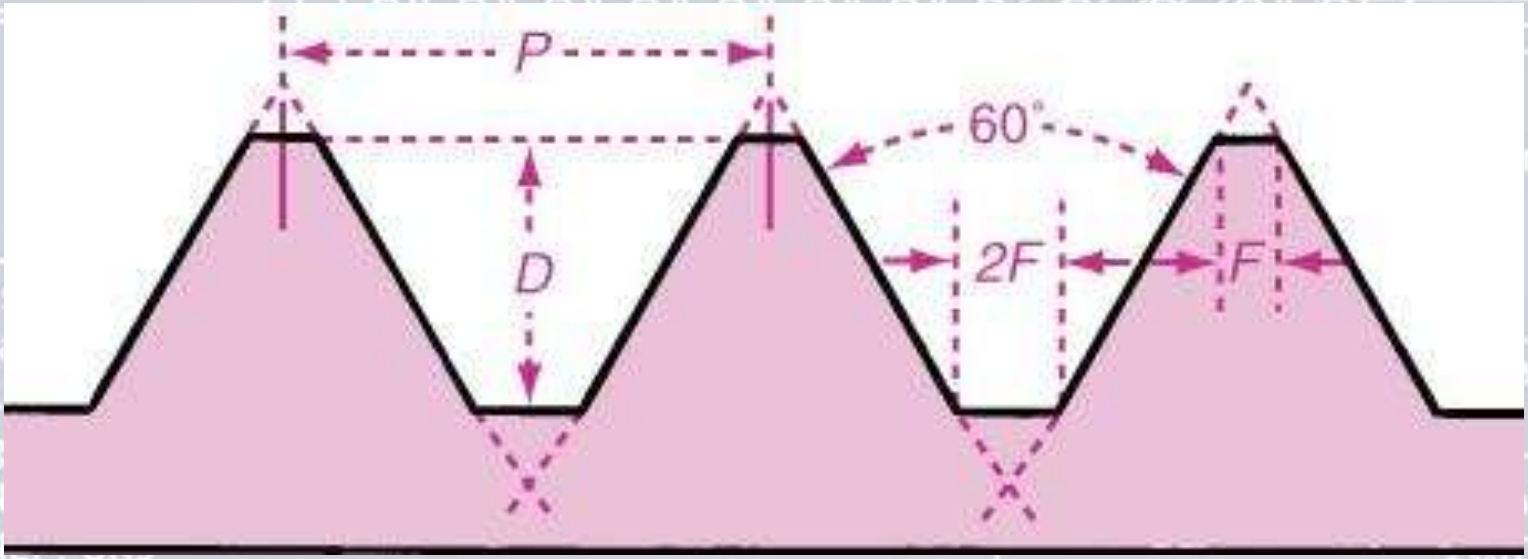
Thread Forms

- ISO Metric
- American National Standard Thread
- British Standard Whitworth (BSW) Thread
- Unified Thread
- Acme Thread
- Square Thread
- Brown & Sharpe Worm Thread
- International Metric thread



ISO Metric Thread

60° included angle
D (Internal) = 0.6143 x pitch
Crest = .125 x pitch
Root = .250 x pitch

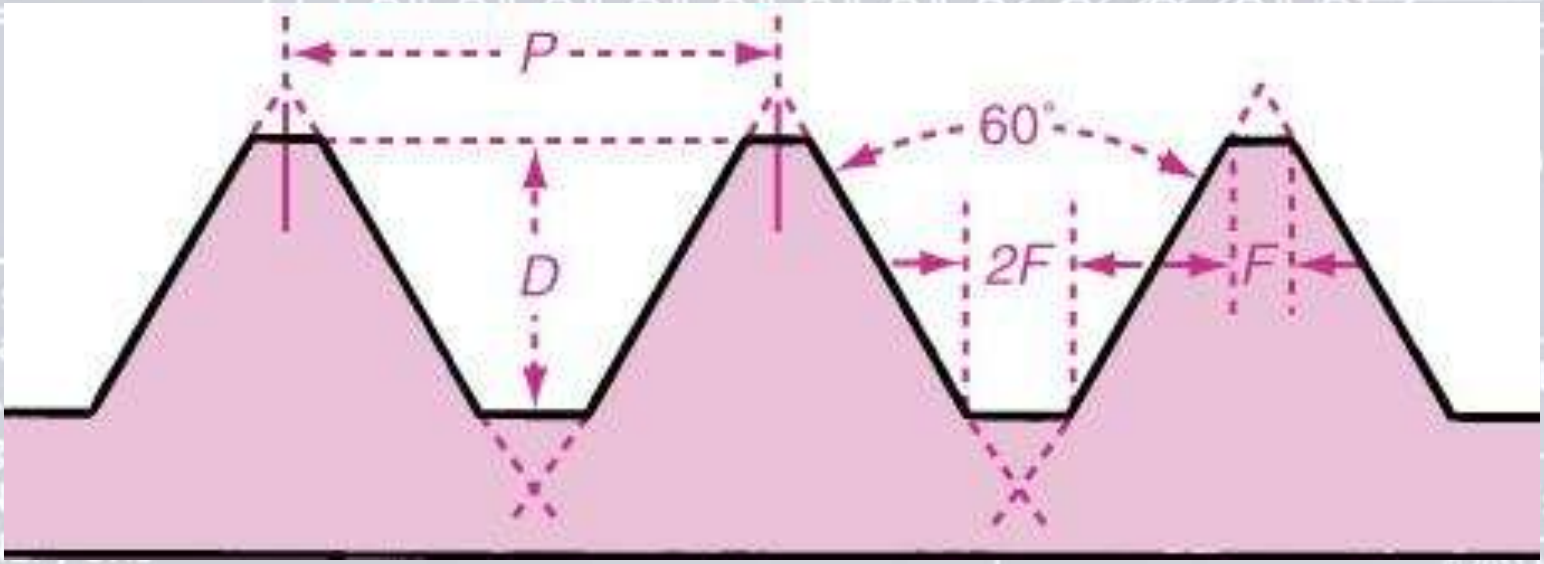


ISO Metric Thread

D (external) = 0.54127 x P

FC = .125 x P

FR = .250 x P



ISO metric pitch and diameter combinations

Nominal Diameter (mm)	Thread Pitch (mm)	Nominal Diameter (mm)	Thread Pitch (mm)
1.6	0.35	20	2.5
2	0.4	24	3
2.5	0.45	30	3.5
3	0.5	36	4
3.5	0.6	42	4.5
4			5
5			5.5

Portion of table taken from textbook

American National Standard Thread

- Divided into four main series, all having same shape and proportions
  - National Coarse (NC)
  - National Fine (NF)
  - National Special (NS)
  - National Pipe (NPT)

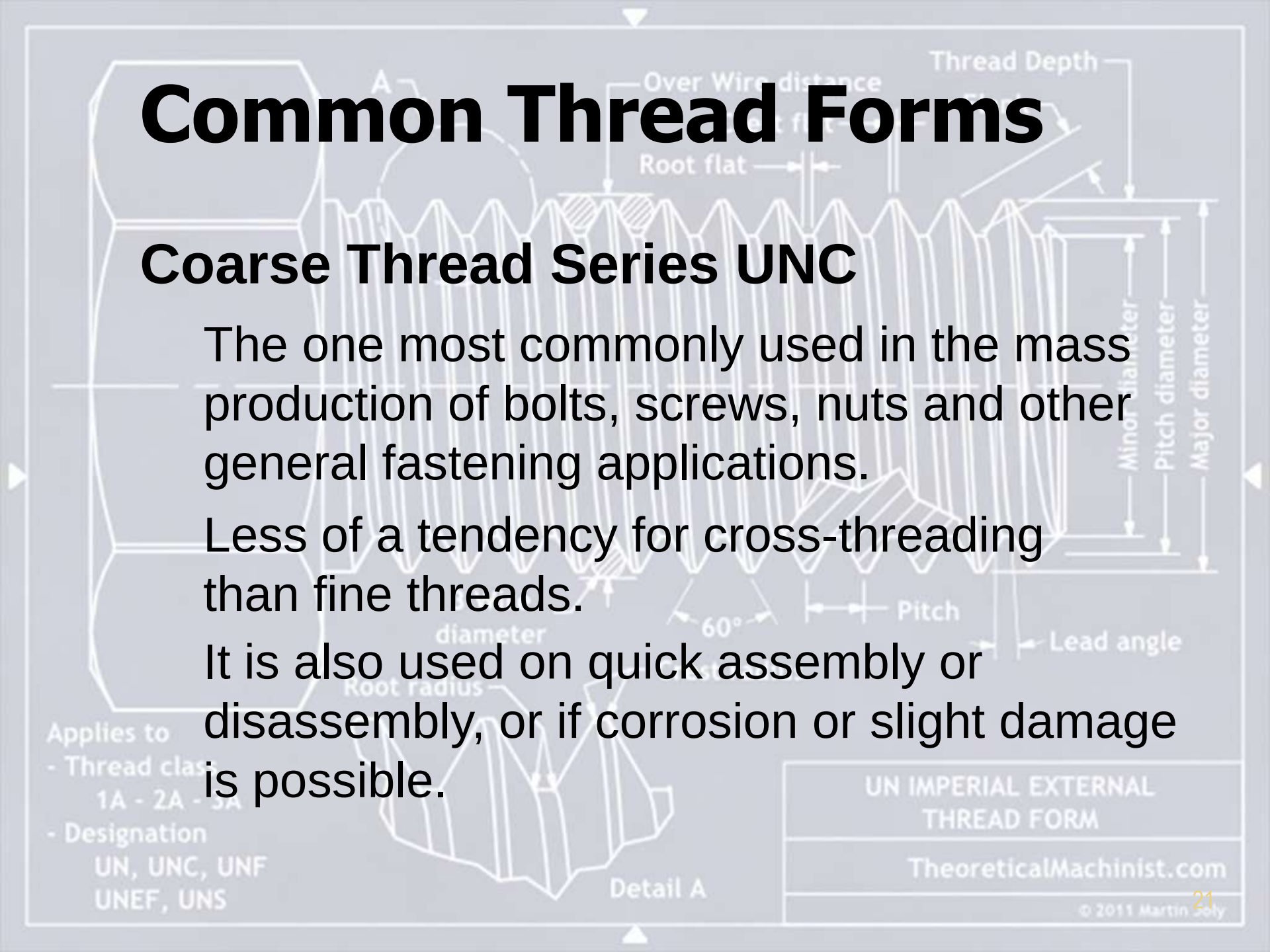
Common Thread Forms

Coarse Thread Series UNC

The one most commonly used in the mass production of bolts, screws, nuts and other general fastening applications.

Less of a tendency for cross-threading than fine threads.

It is also used on quick assembly or disassembly, or if corrosion or slight damage is possible.



Common Thread Forms

Fine Thread Series UNF

When used on external threads have greater tensile stress area than coarse threads of the same size.

Resists stripping out better than coarse threads in areas where the external and mating internal threads are subjected to loads equal to or greater than the capacity of the screw or bolt.

Used were the length of engagement is limited

Common Thread Forms

UNIFIED SCREW THREADS

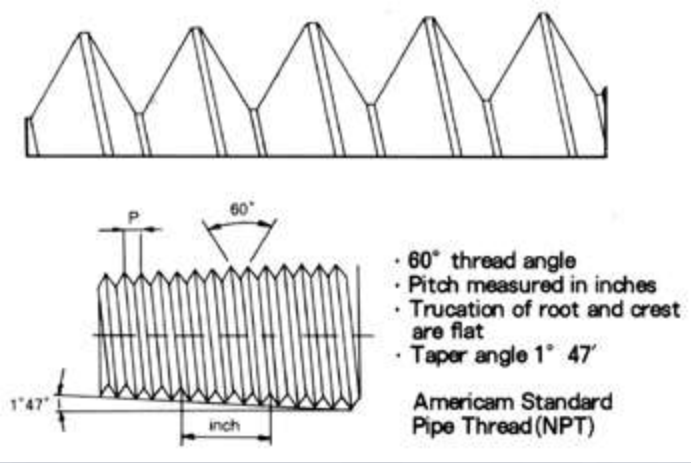
Unified National Coarse (UNC)					Unified National Fine (UNF)				
Size of Screw	Threads per Inch	Major (Outside) Diameter of Thread	Tap Drill Size	Decimal Equivalent of Drill	Size of Screw	Threads per Inch	Major (Outside) Diameter of Thread	Tap Drill Size	Decimal Equivalent of Drill
					0	80	0.060	3/64	0.0469
1	64	0.073	53	0.0595	1	72	0.073	53	0.0595
2	56	0.086	50	0.0700	2	64	0.086	50	0.0700
3	48	0.099	47	0.0785	3	56	0.099	45	0.0820
4	40	0.112	43	0.0890	4	48	0.112	42	0.0935
5	40	0.125	38	0.1015	5	44	0.125	37	0.1040
6	32	0.138	36	0.1065	6	40	0.138	33	0.1130
8	32	0.164	29	0.1360	8	36	0.164	29	0.1360
10	24	0.190	25	0.1495	10	32	0.190	21	0.1590
12	24	0.216	16	0.1770	12	28	0.216	14	0.1820
1/4	20	0.250	7	0.2010	1/4	28	0.250	3	0.2130
5/16	18	0.3125	F	0.2570	5/16	24	0.3125	1	0.2720
3/8	16	0.375	5/16	0.3125	3/8	24	0.375	Q	0.3320
7/16	14	0.4375	U	0.3680	7/16	20	0.4375	25/64	0.3906
1/2	13	0.500	27/64	0.4219	1/2	20	0.500	29/64	0.4531
9/16	12	0.5625	31/64	0.4844	9/16	18	0.5625	33/64	0.5156
5/8	11	0.625	17/32	0.5312	5/8	18	0/625	37/64	0.5781
3/4	10	0.750	21/32	0.6562	3/4	16	0.750	11/16	0.6875
7/8	9	0.875	49/64	0.7656	7/8	14	0.875	13/16	0.8125
1"	8	1.000	7/8	0.875	1"	12	1.000	59/64	0.9219

Common Thread Forms

Taper Pipe Series NPT

The taper of the external thread forms a joint with the taper of the internal thread.

When used with a sealer (such as pipe dope or teflon tape) will produce a pressure tight joint.



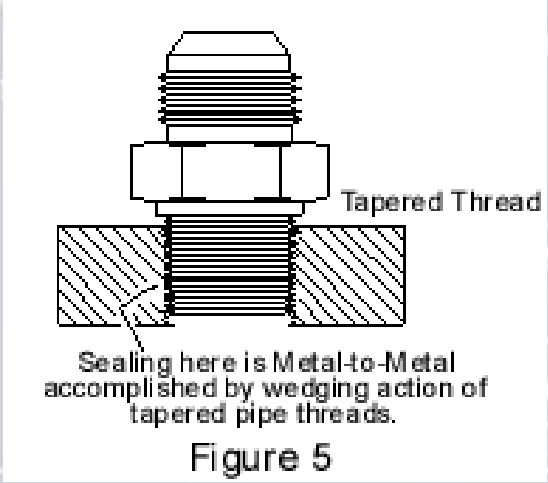
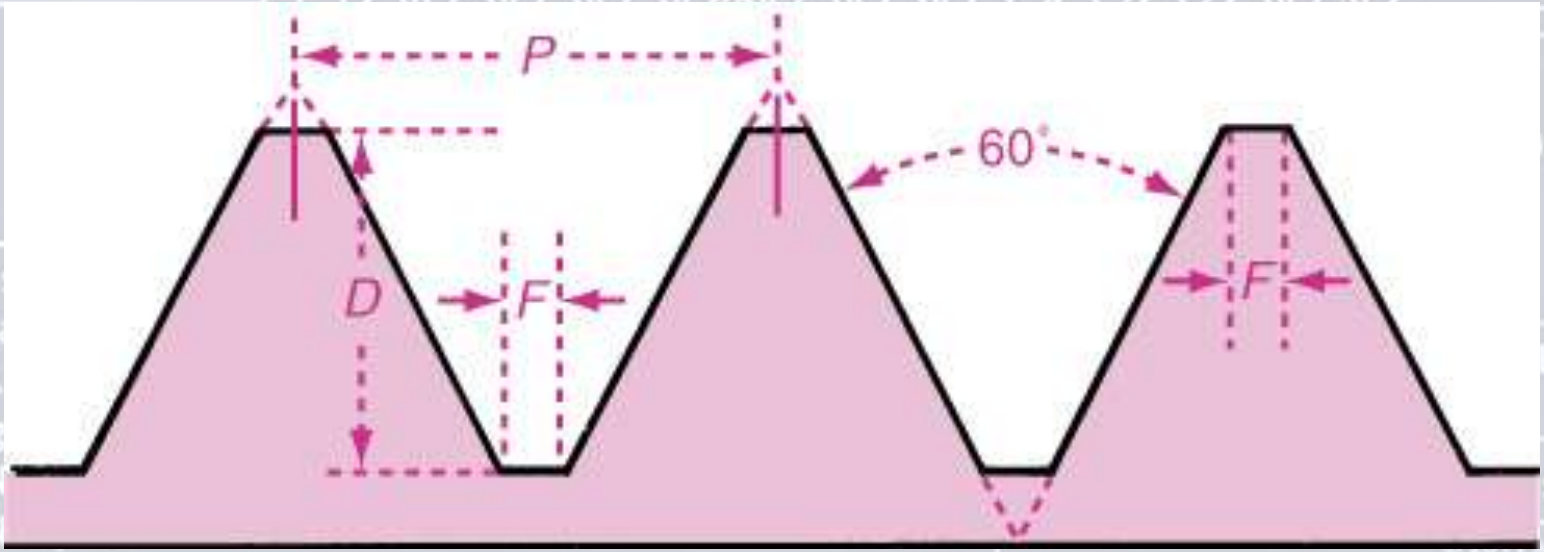


Figure 5

American National Standard Thread

$$D = .6134 \text{ x } P \text{ or } \frac{.6134}{N}$$

$$F = .125 \text{ x } P \text{ or } \frac{.125}{N}$$

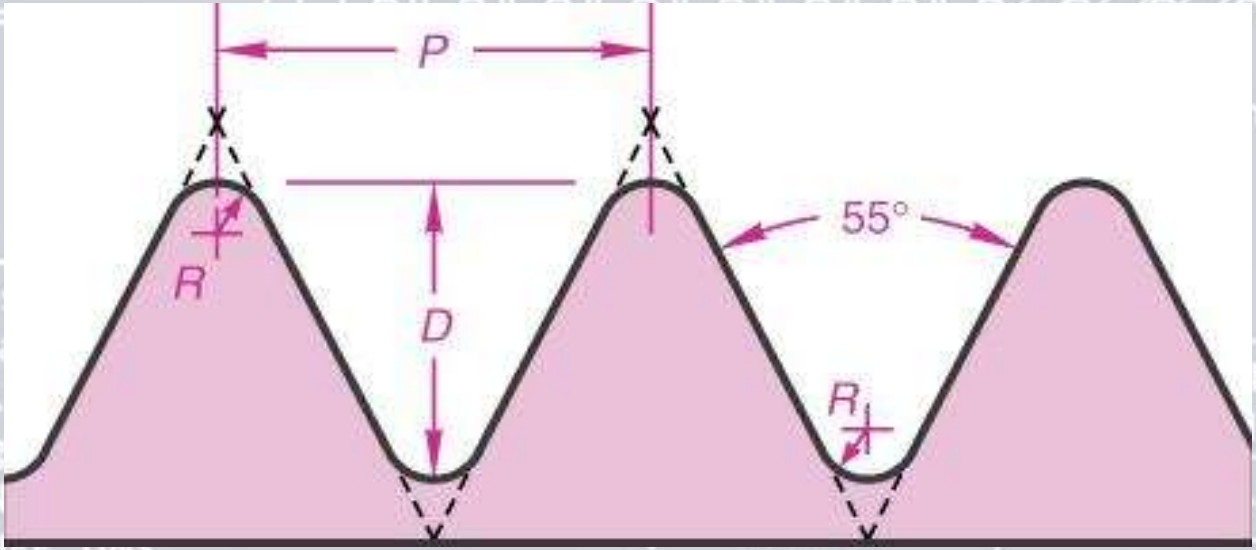


British Standard Whitworth (BSW) Thread

- Application is same as for American National form thread

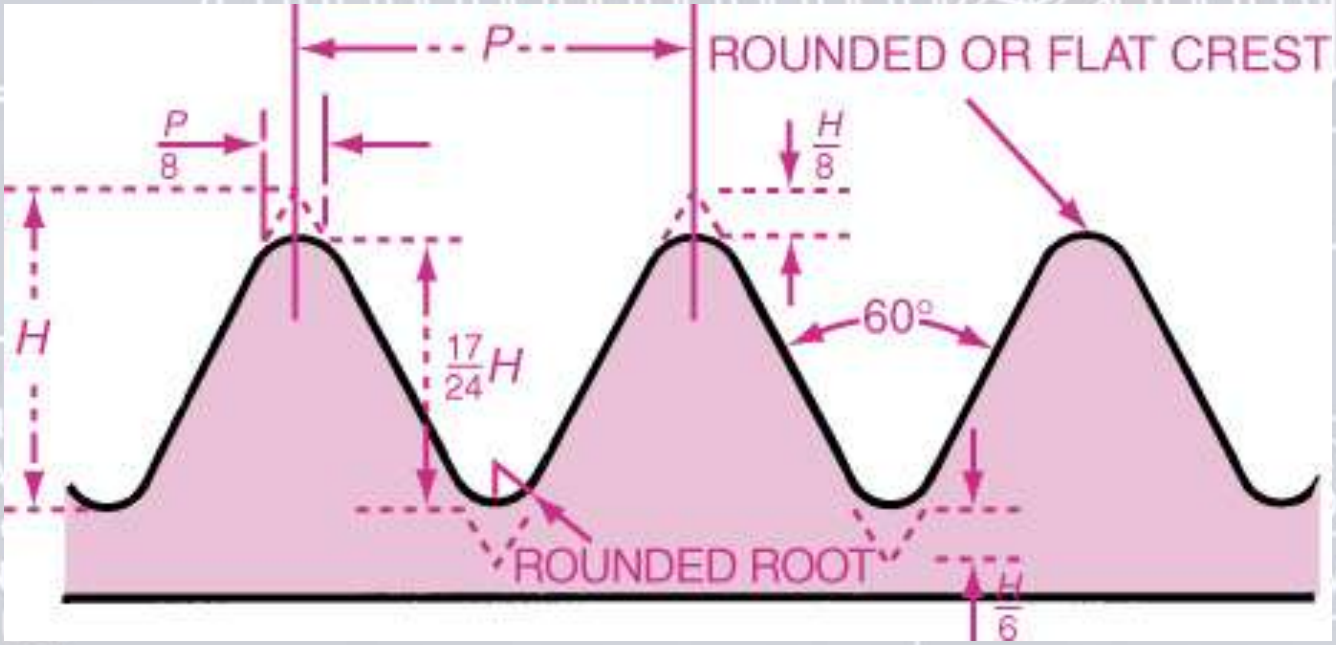
$$D = .6403 \times P \text{ or } \frac{.6403}{N}$$

$$R = .1373 \times P \text{ or } \frac{.1373}{N}$$

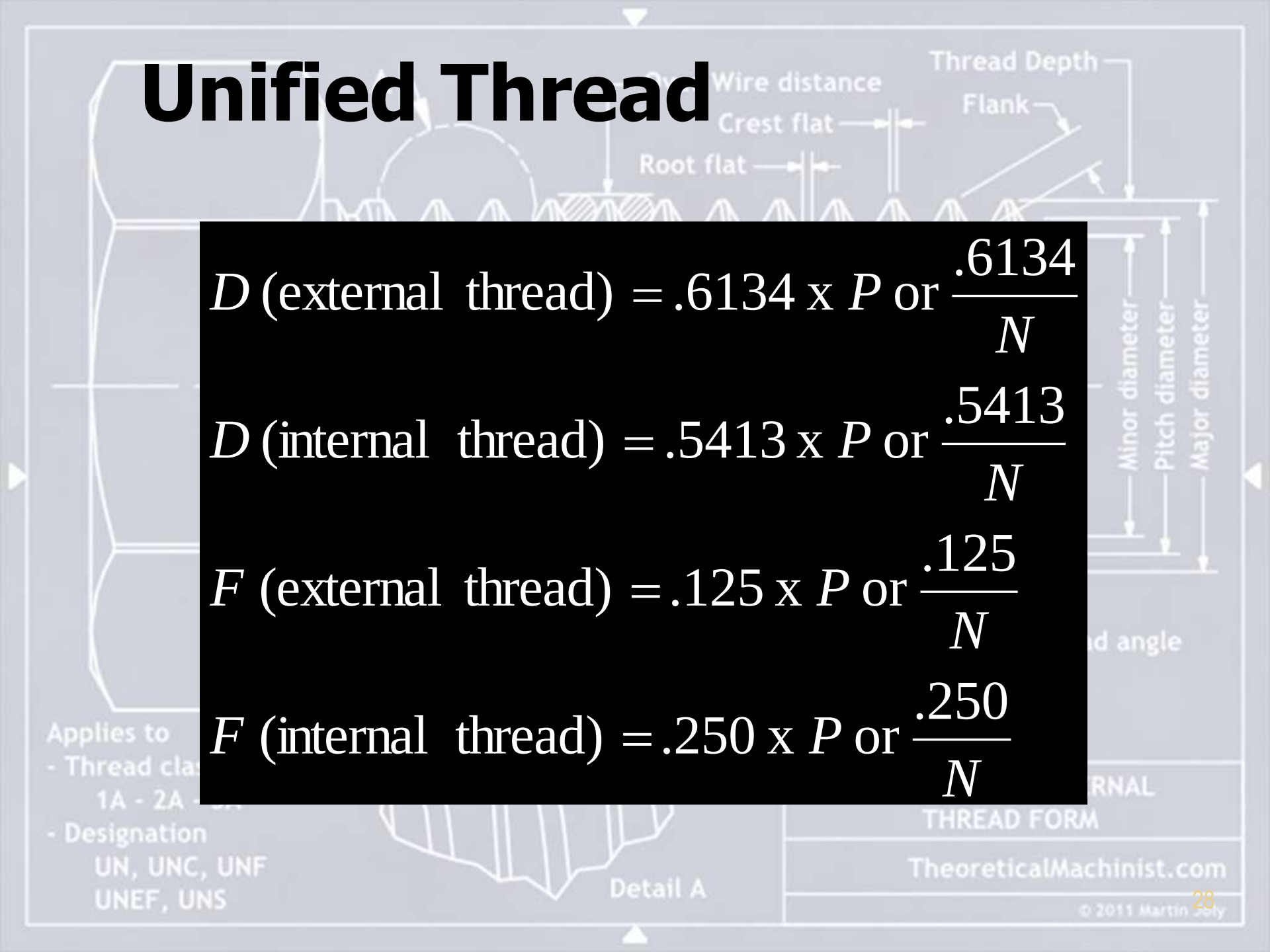


Unified Thread

- Developed by U.S., Britain, and Canada for standardized thread system
- Combination of British Standard Whitworth and American National Standard Thread



Unified Thread



$$D\,(\text{external thread}) = .6134 \times P \text{ or } \frac{.6134}{N}$$

$$D\,(\text{internal thread}) = .5413 \times P \text{ or } \frac{.5413}{N}$$

$$F\,(\text{external thread}) = .125 \times P \text{ or } \frac{.125}{N}$$

$$F\,(\text{internal thread}) = .250 \times P \text{ or } \frac{.250}{N}$$

Acme Screw Thread

- Replacing square thread in many cases
- Used for feed screws, jacks, and vises

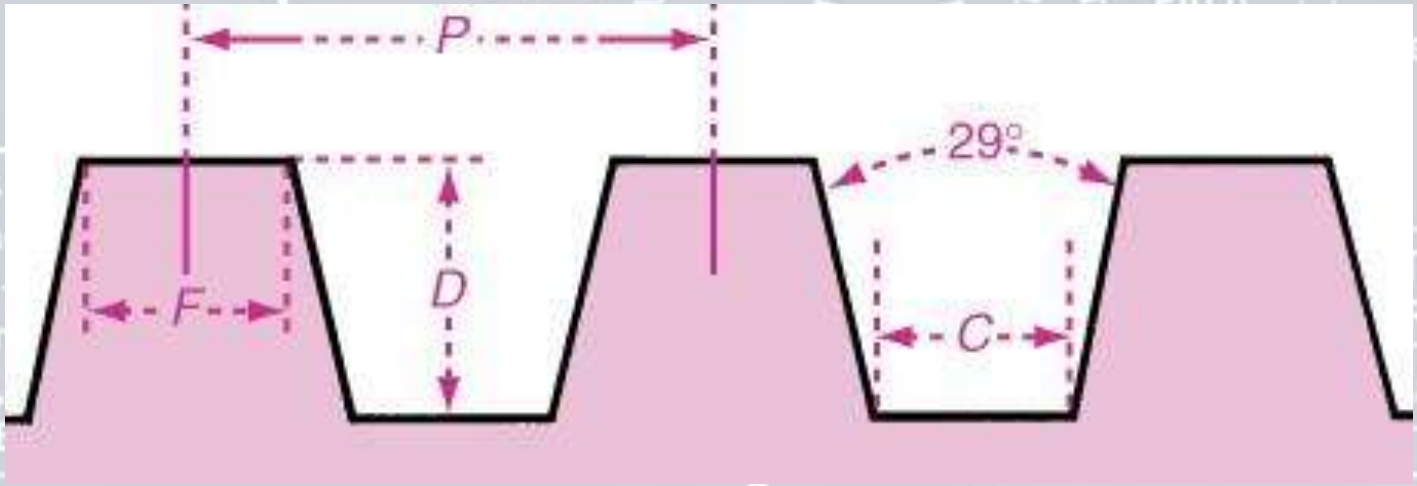
D = minimum .500P

= maximum .500P + 0.010

$F = .3707P$

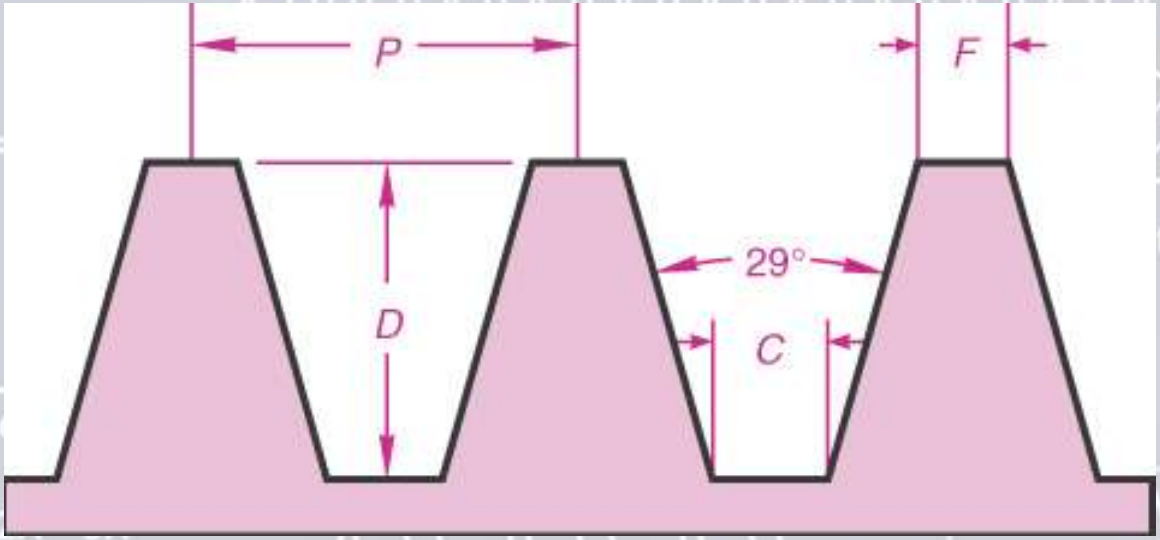
$C = .3707P - .0052$

(for maximum depth)



Brown & Sharpe Worm Thread

Used to mesh worm gears and transmit motion between two shafts at right angles to each other but not in same plane



D = .6866P

F = .335P

C = .310P

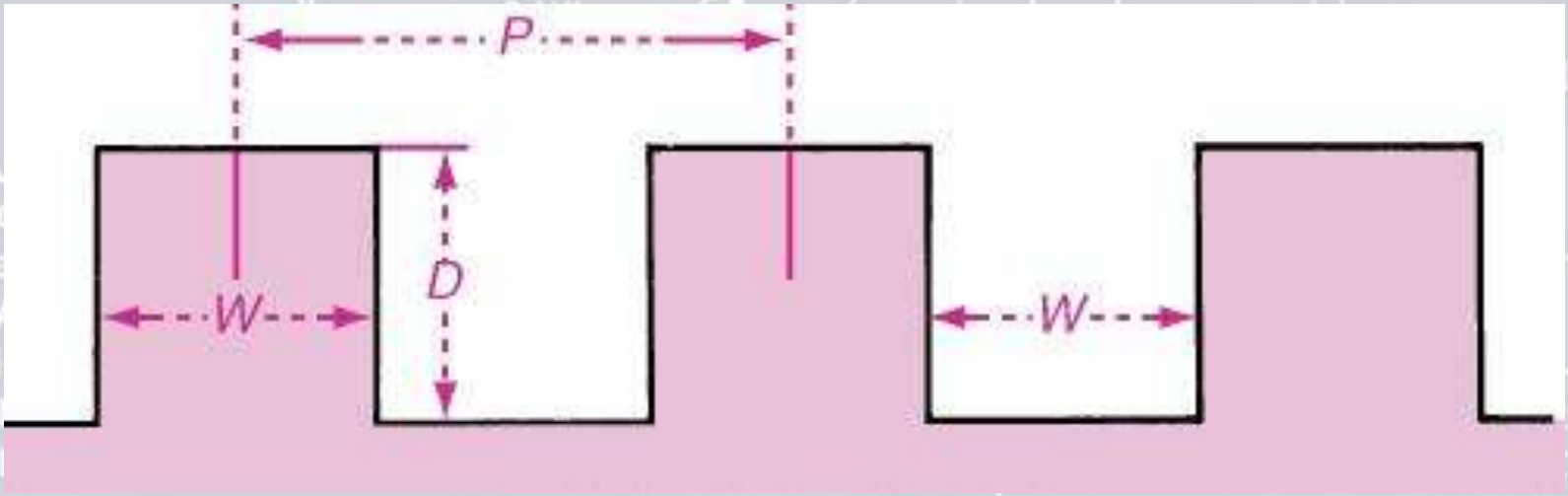
Square Thread

- Being replaced by Acme thread because of difficulty in cutting it
- Often found on vises and jack screws

D = .500P

F = .500P

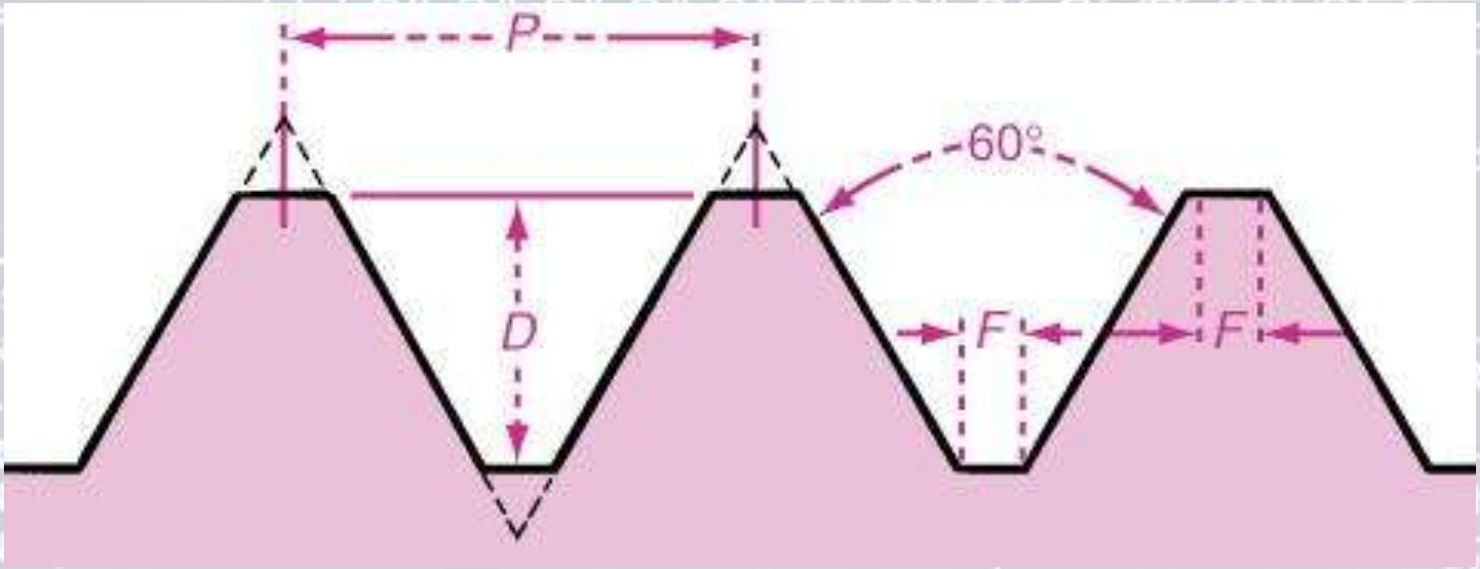
C = .500P + .002



International Metric thread

- Standardized thread used in Europe

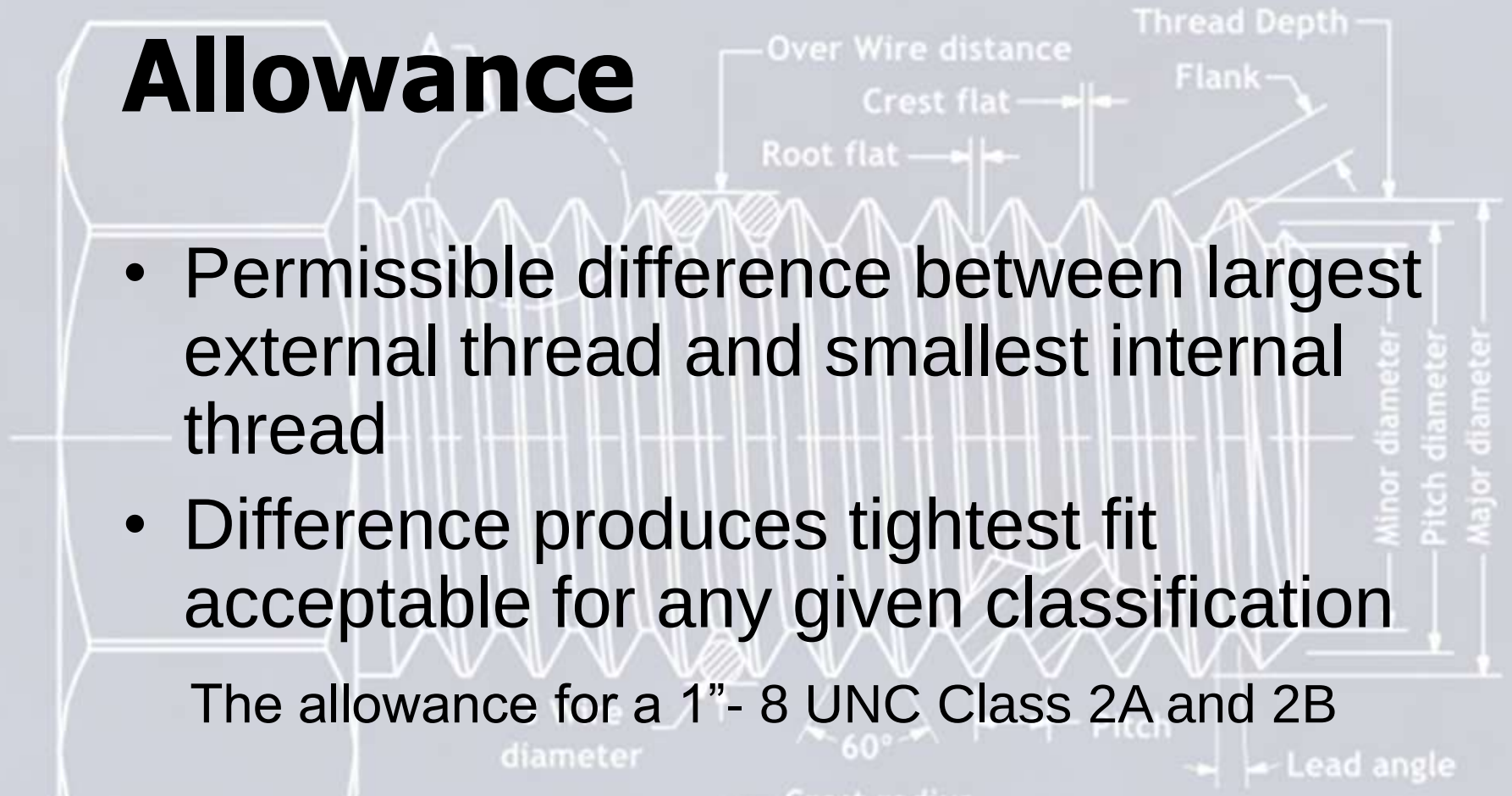
D = 0.7035P (maximum) F = 0.125P
= 0.6855P (minimum) R = 0.0633P (maximum)
= 0.054P (minimum)



Thread Fits and Classifications

- Fit
  - Relationship between two mating parts
  - Determined by amount of clearance or interference when they are assembled
- Nominal size
  - Designation used to identify size of part
- Actual size
  - Measured size of thread or part
  - Basic size: size from which tolerances are set

Allowance



- Permissible difference between largest external thread and smallest internal thread
- Difference produces tightest fit acceptable for any given classification

The allowance for a 1”- 8 UNC Class 2A and 2B

Minimum pitch diameter of the internal thread (2B) = .9188 in.

Maximum pitch diameter of the external thread (2A) = .9168 in.

Allowance = .002 in.

Tolerance

- Variation permitted in part size
- Total tolerance is sum of plus and minus tolerances
- In Unified and National systems, tolerance is plus on external threads and minus on internal threads

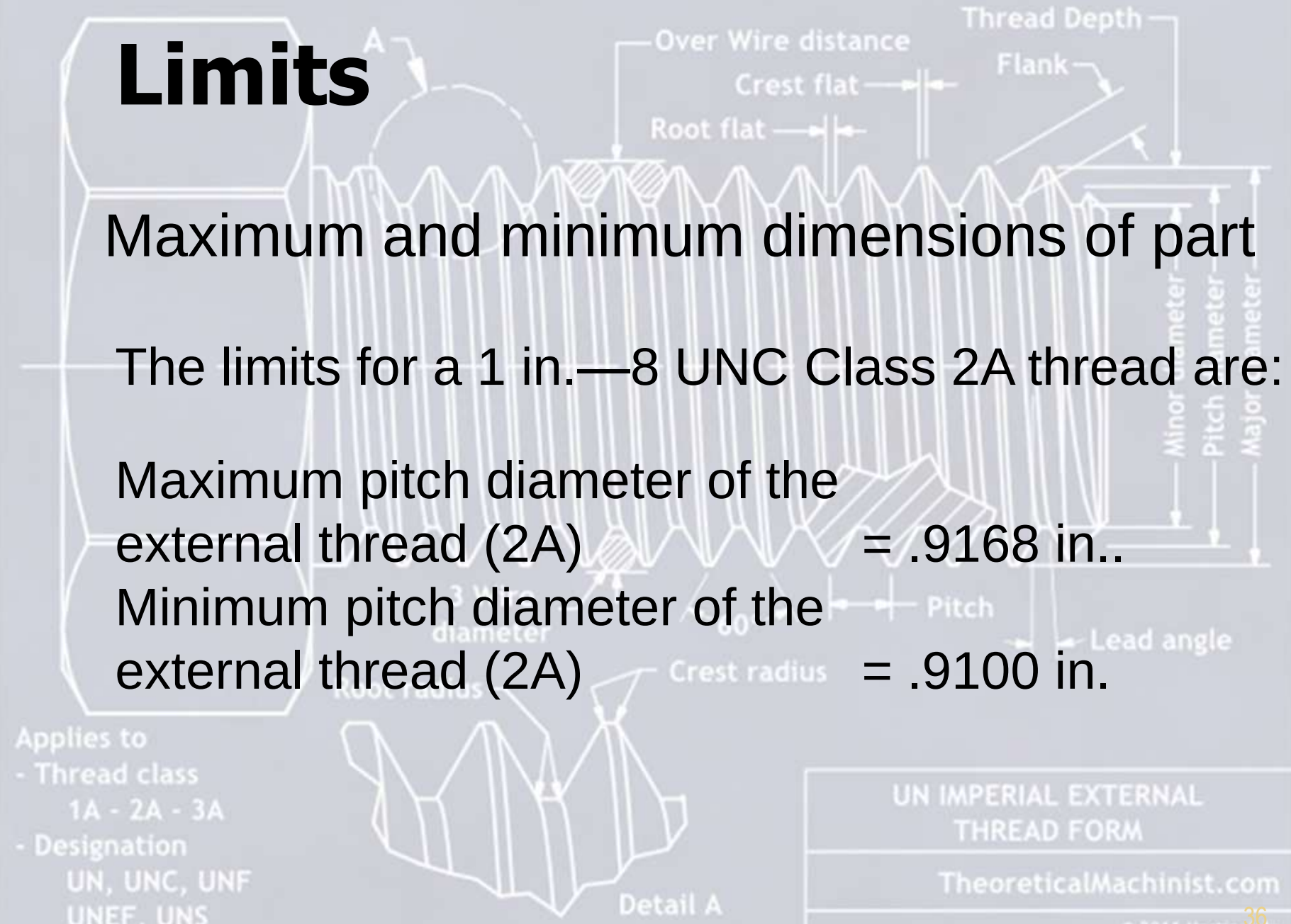
The tolerance for a 1 in.—8 UNC Class 2A thread is:

Maximum pitch diameter of the external thread (2A) = .9168 in.

Minimum pitch diameter of the external thread (2A) = .9100 in.

Tolerance = .0068 in.

Limits



Maximum and minimum dimensions of part

The limits for a 1 in.—8 UNC Class 2A thread are:

Maximum pitch diameter of the external thread (2A) = .9168 in..

Minimum pitch diameter of the external thread (2A) = .9100 in.

ISO Metric Tolerances and Allowances

- ISO metric screw thread tolerance system provides for allowances and tolerances defined by tolerance grades, tolerance positions, and tolerance classes
- Tolerance grades specified numerically
  - Medium tolerance indicated by number 6, number below 6 indicates finer tolerance and number above 6 indicates greater tolerance

Tolerance Example:

An external metric thread may be designated as follows:

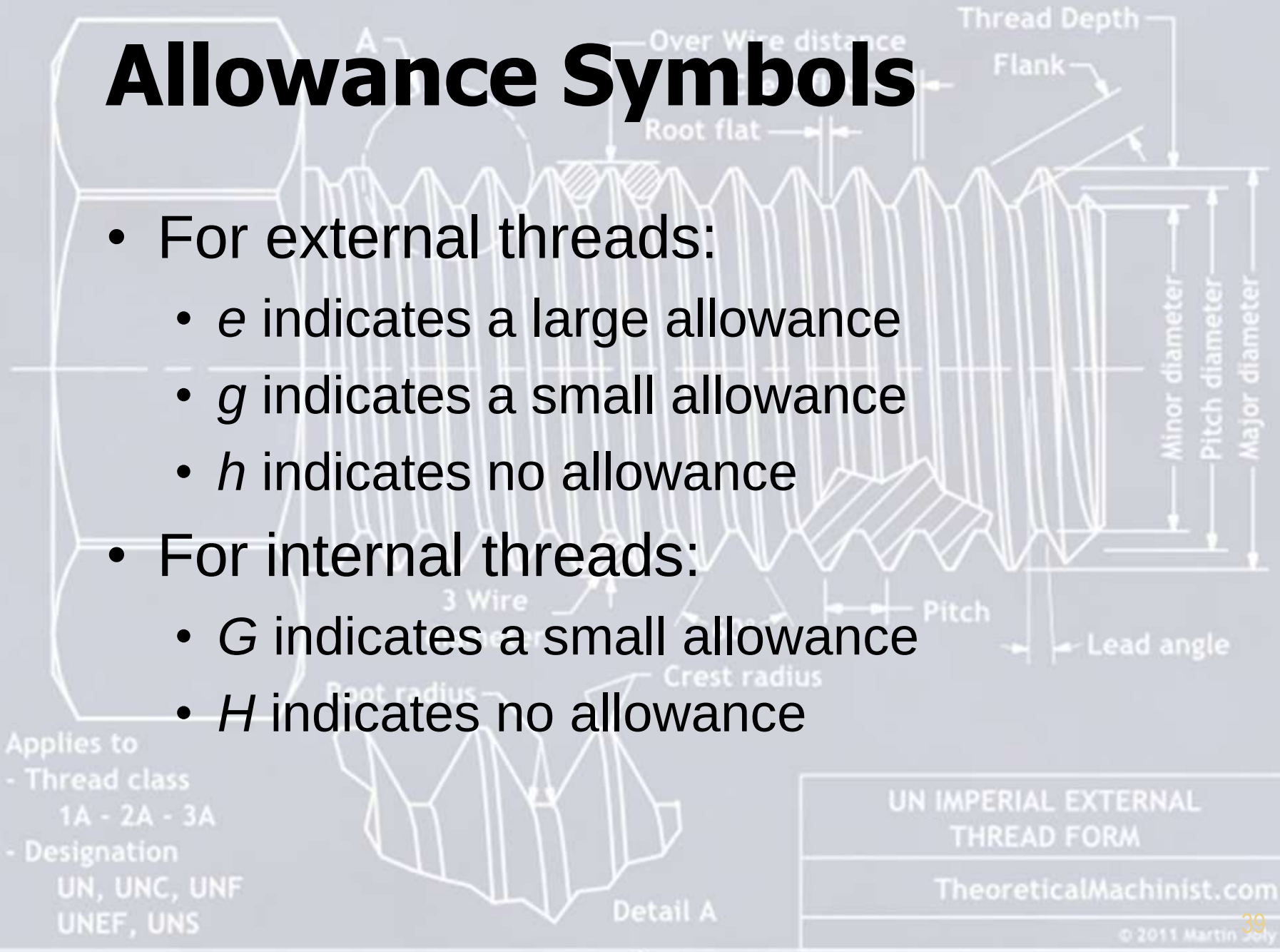
	Nominal Size		Pitch		Pitch Diameter Tolerance	Outside Diameter Tolerance
Metric						
M	6	X	0.75	-	5*g*	6*g*

The thread fit between mating parts is indicated by internal thread designation followed by the external thread tolerance:

M 20 X 2 - 6*H*/5*g* 6*g*

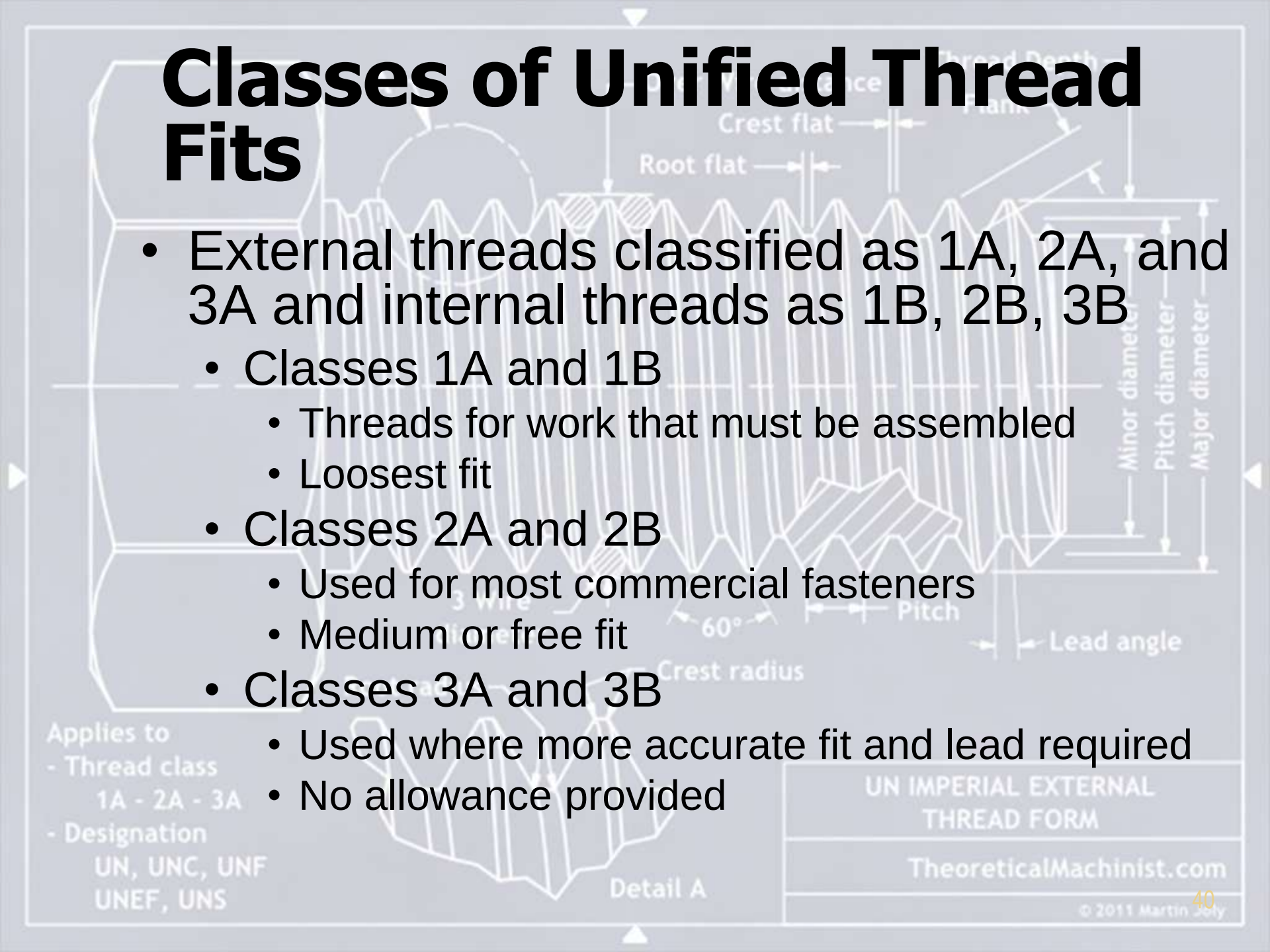
Allowance Symbols

- For external threads:
  - *e* indicates a large allowance
  - *g* indicates a small allowance
  - *h* indicates no allowance
- For internal threads:
  - *G* indicates a small allowance
  - *H* indicates no allowance



Classes of Unified Thread Fits

- External threads classified as 1A, 2A, and 3A and internal threads as 1B, 2B, 3B
  - Classes 1A and 1B
    - Threads for work that must be assembled
    - Loosest fit
  - Classes 2A and 2B
    - Used for most commercial fasteners
    - Medium or free fit
  - Classes 3A and 3B
    - Used where more accurate fit and lead required
    - No allowance provided



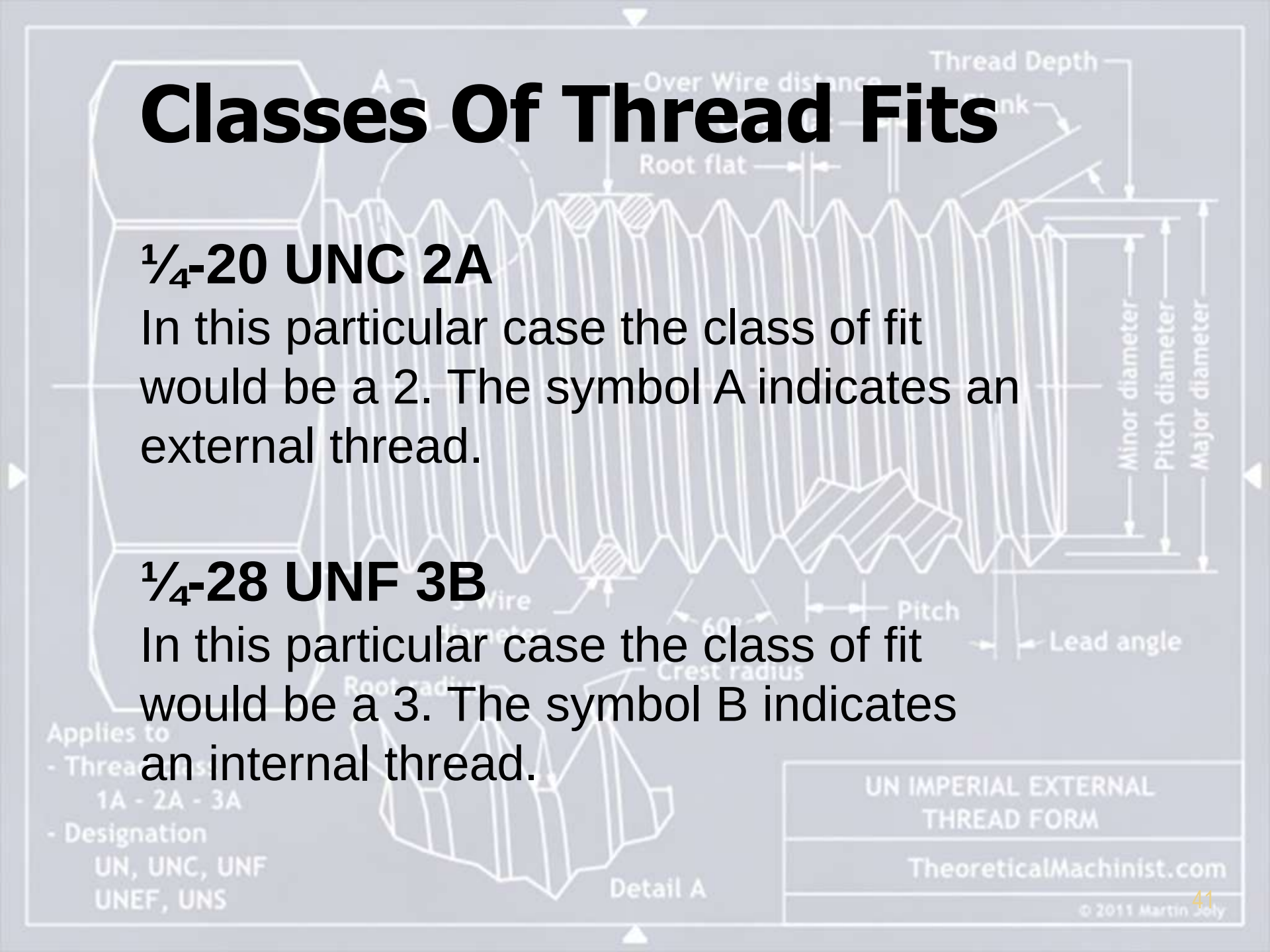
Classes Of Thread Fits

¼-20 UNC 2A

In this particular case the class of fit would be a 2. The symbol A indicates an external thread.

¼-28 UNF 3B

In this particular case the class of fit would be a 3. The symbol B indicates an internal thread.



Thread Calculations

Calculate pitch, depth, minor diameter, and width of flat for a ¾”-10 UNC thread.

D = single depth of thread

P = pitch

$$P = \frac{1}{tpi} = \frac{1}{10} = .100 \text{ in.}$$

$$D = .61343 \times P$$

$$= .61343 \times .100 = .061 \text{ in.}$$

$$\text{Minor dia} = \text{Major dia} - (D + D)$$

$$= .75 - (.061 + .061)$$

$$= .628 \text{ in.}$$

$$\text{Width of flat} = \frac{P}{8} = \frac{1}{8} \times \frac{1}{10}$$

$$= .0125 \text{ in.}$$

Thread Calculations

What is the depth, minor diameter, crest and root for an M 6.3 X 1 thread?

P = pitch = 1 mm

D = 0.54127 x 1

= 0.54 mm

Width of root = 0.25 x P

= 0.25 x 1

= 0.25 mm

Minor dia = Major dia - (D + D)

= 6.3 - (.54 + .54)

= 5.22 mm

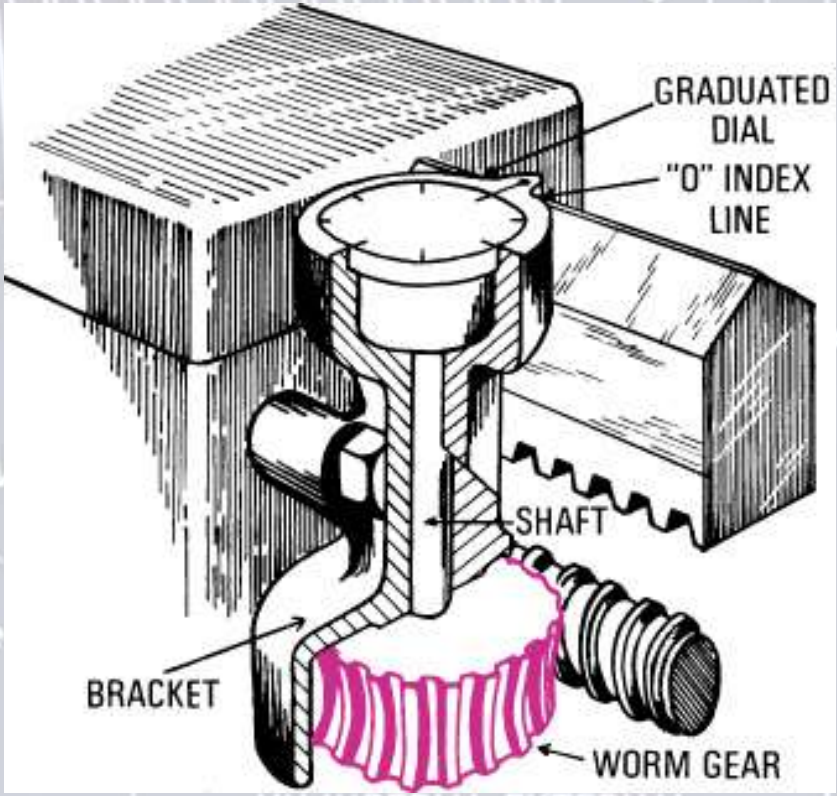
Width of crest = 0.125 x P

= 0.125 x 1

= 0.125 mm

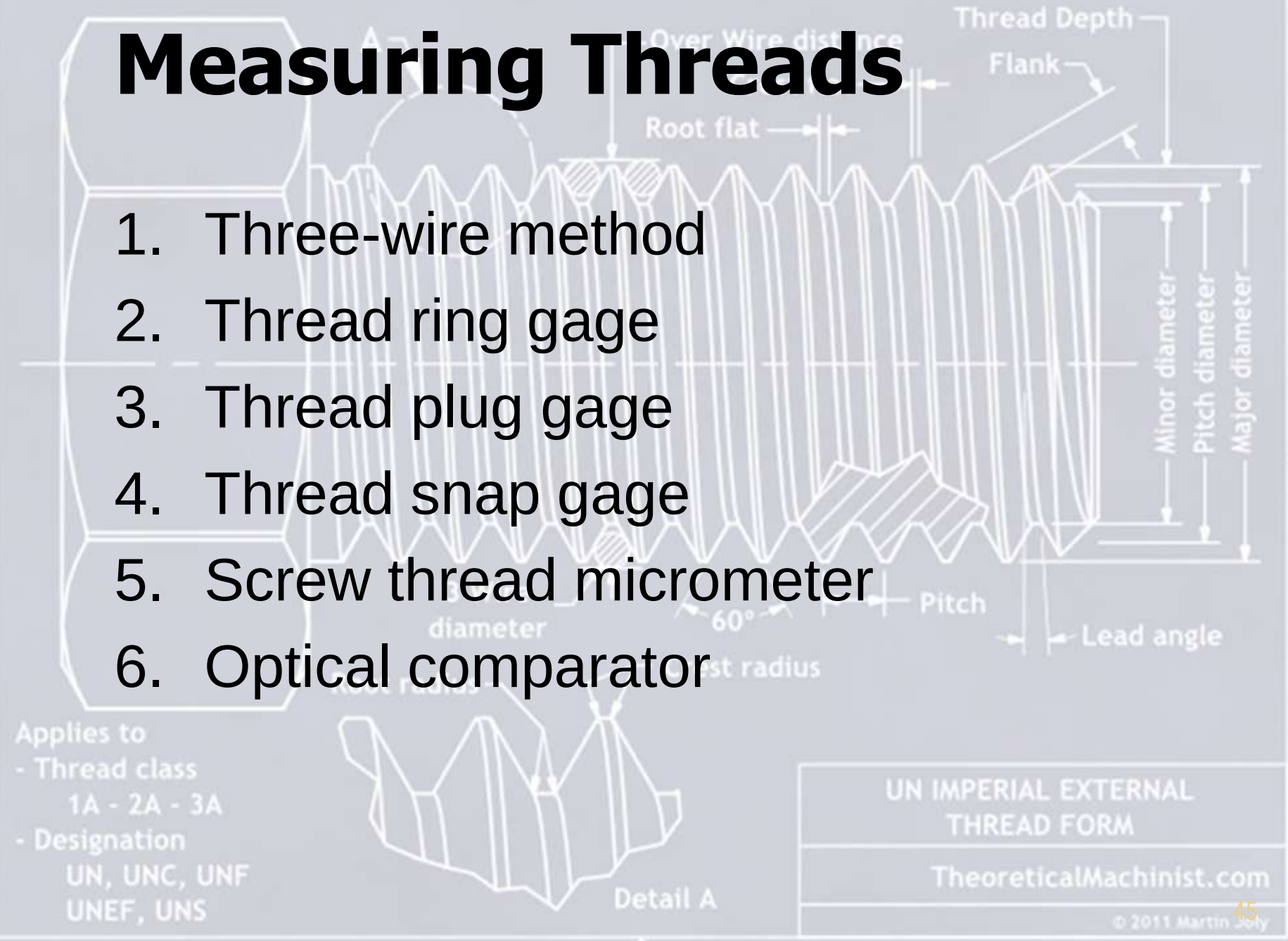
Thread-Chasing dial

- Lathe spindle and lead screw must be in same relative position for each cut
  - Thread-chasing dial attached to carriage for this purpose
- Dial has eight divisions
  - Even threads use any division
  - Odd threads either numbered or unnumbered: not both



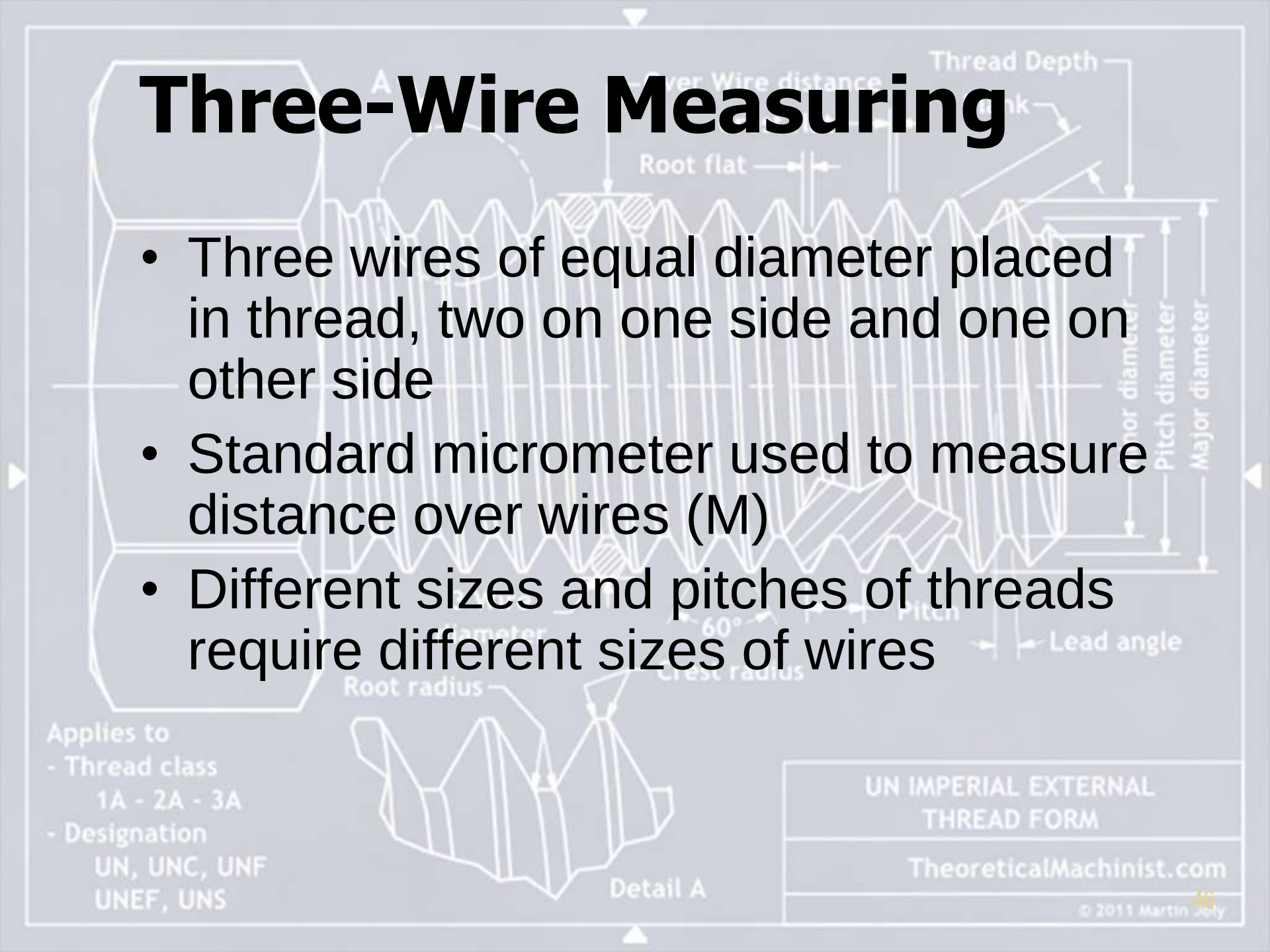
Measuring Threads

1. Three-wire method
2. Thread ring gage
3. Thread plug gage
4. Thread snap gage
5. Screw thread micrometer
6. Optical comparator

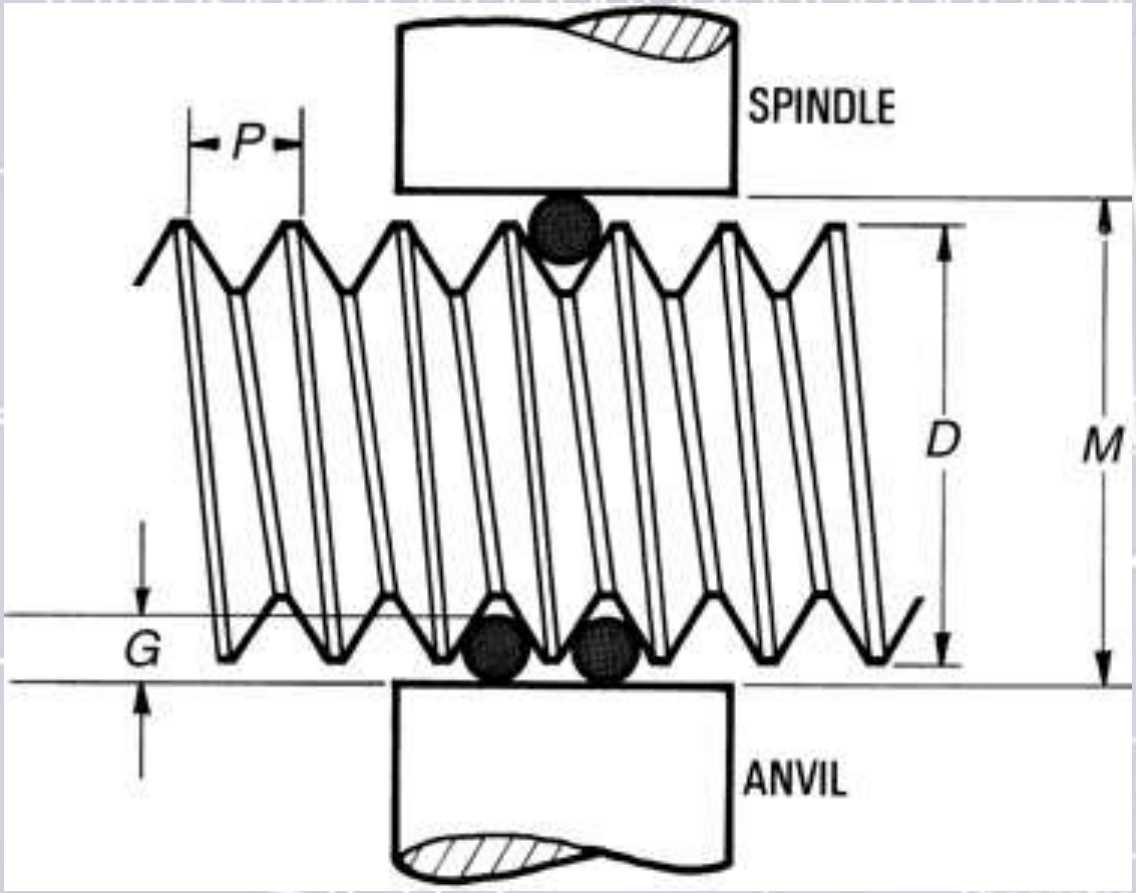


Three-Wire Measuring

- Three wires of equal diameter placed in thread, two on one side and one on other side
- Standard micrometer used to measure distance over wires (M)
- Different sizes and pitches of threads require different sizes of wires



The Three-Wire Method of Measuring 60º Threads



Measurement with Wires

$$M = D + 3G - \frac{1.5155}{N}$$

where M = measurement over the wires

D = major diameter of the thread

G = diameter of the wire size used

N = number of *tpi*

Any of the following formulas can be used to calculate G:

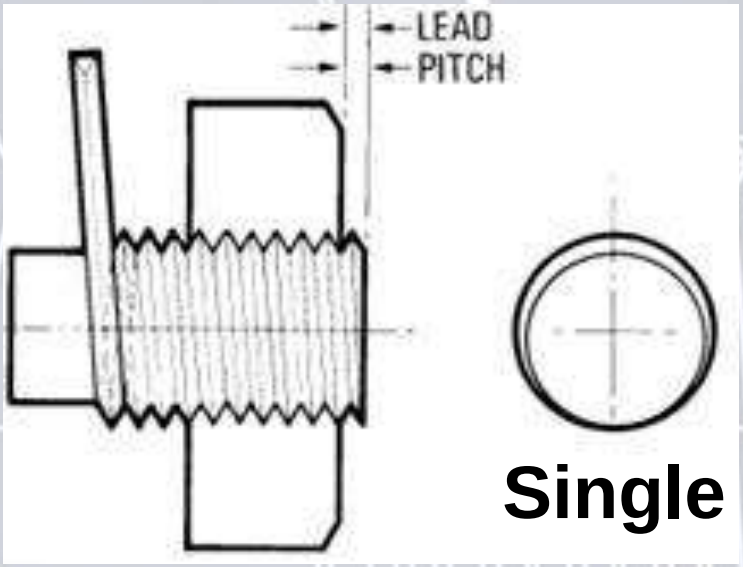
$$\text{Largest wire} = \frac{1.010}{N} \text{ or } 1.010P$$

$$\text{Best-size wire} = \frac{.57735}{N} \text{ or } .57735P$$

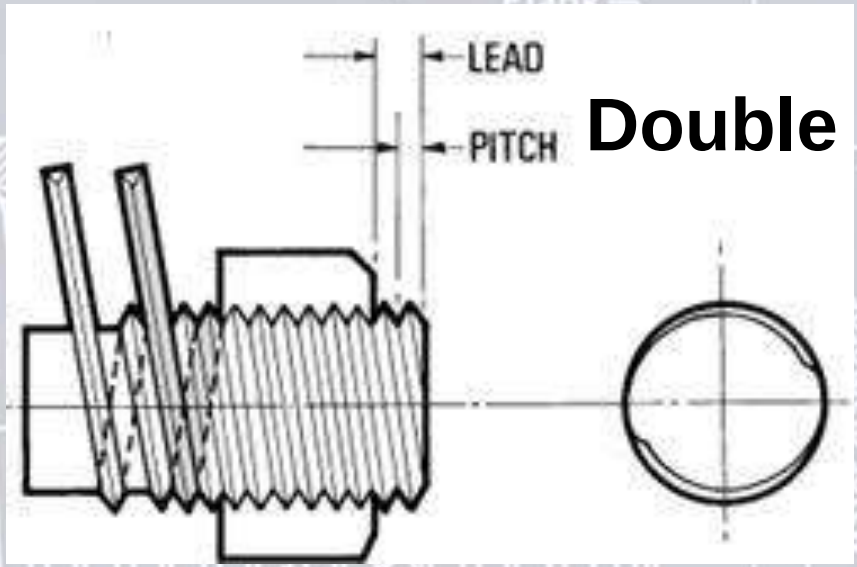
$$\text{Smallest wire} = \frac{.505}{N} \text{ or } .505P$$

Multiple Threads

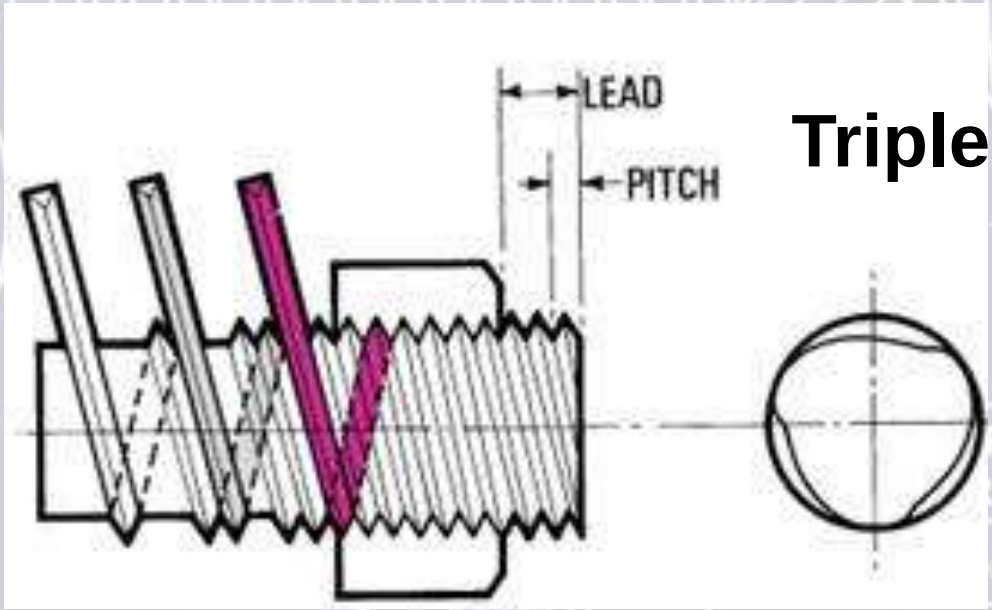
- May be double, triple or quadruple, depending on number of starts around periphery of work
- Pitch: distance from point on one thread to corresponding point on next thread
- Lead: distance nut advances lengthwise in one complete revolution
  - Single-start: pitch and lead equal
  - Double-start: lead twice the pitch
  - Triple-start: lead three times pitch



Single



Double

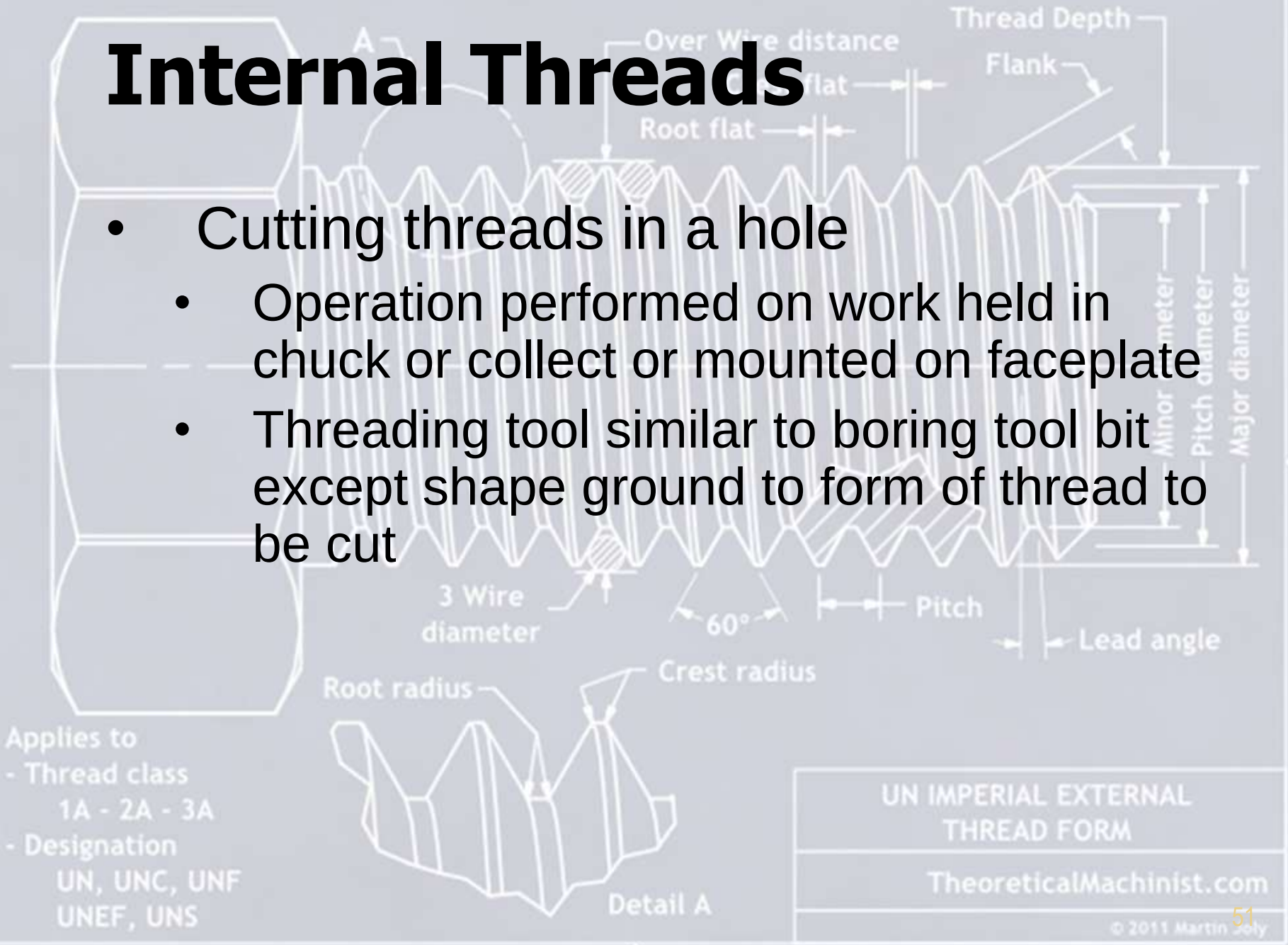


Triple

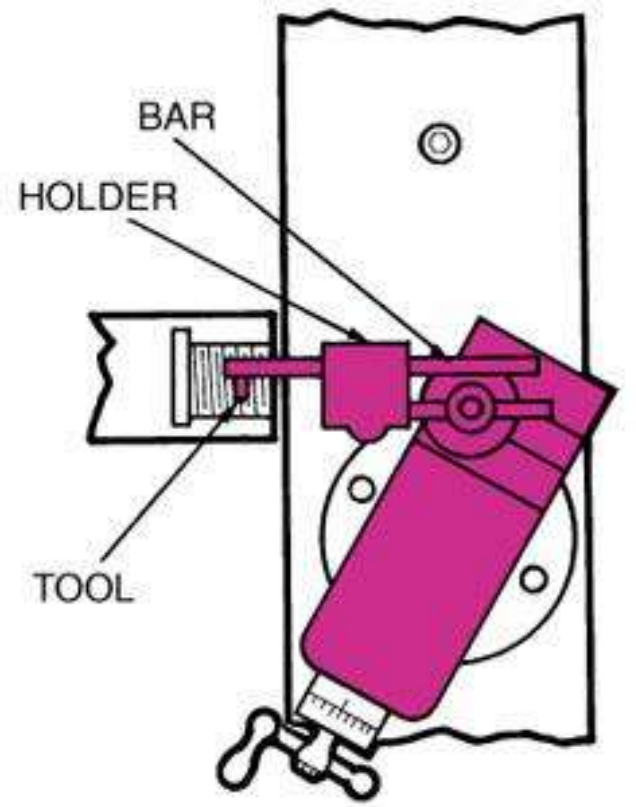
Applies to
- Thread class
  1A - 2A - 3A
- Designation
  UN, UNC, UNF
  UNEF, UNS

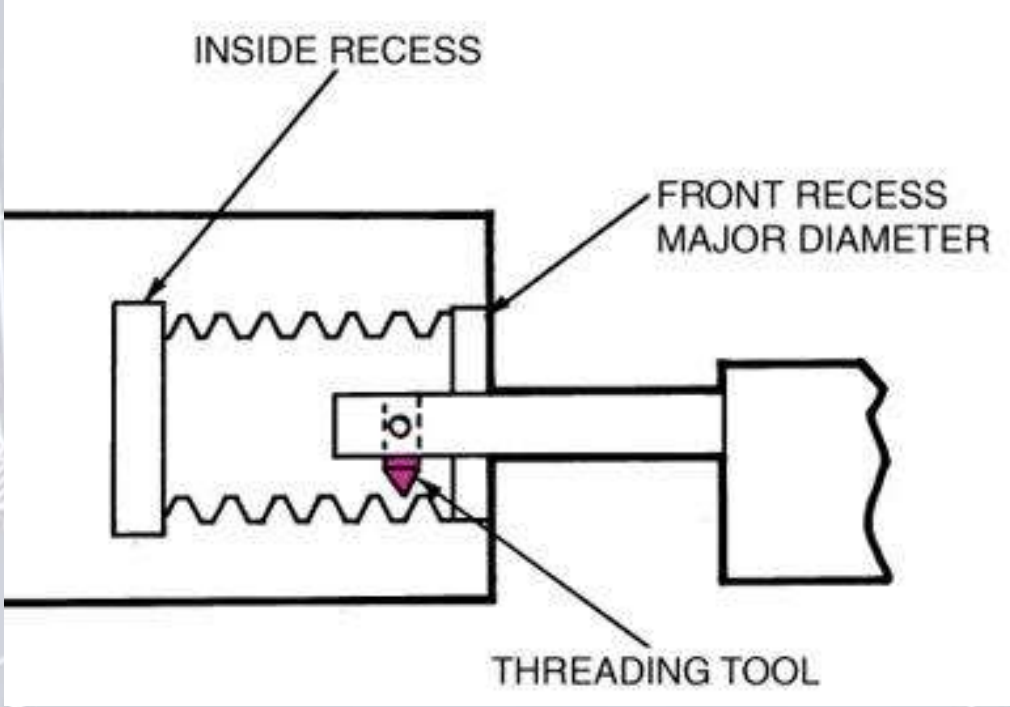
Internal Threads

- Cutting threads in a hole
  - Operation performed on work held in chuck or collect or mounted on faceplate
  - Threading tool similar to boring tool bit except shape ground to form of thread to be cut



Internal Threads





The compound rest is set at 29º to the left for cutting right-hand internal threads.