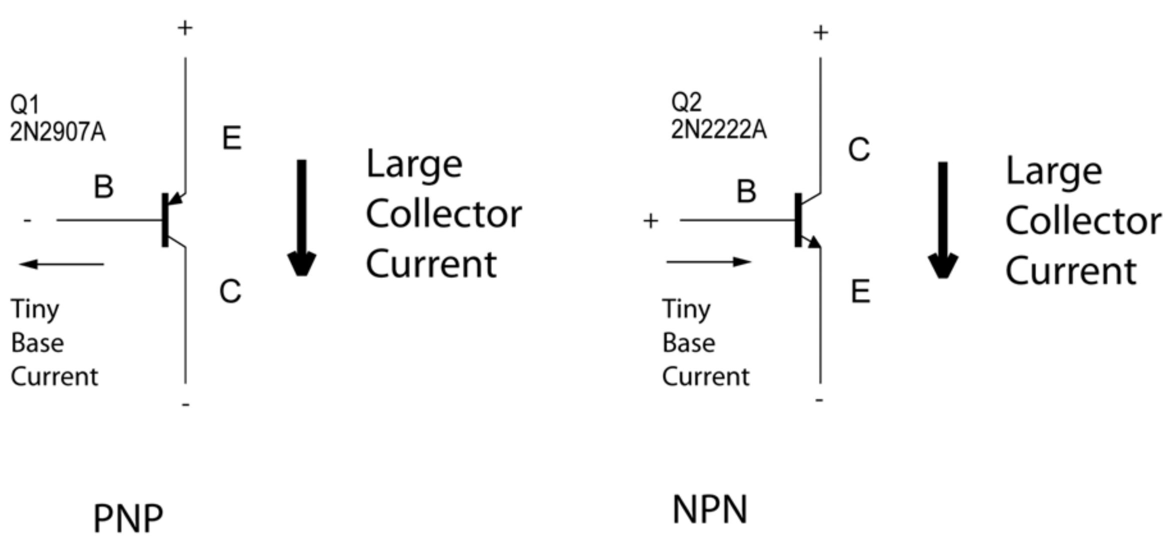
Electronics Review 2
Cornerstone Electronics Technology and Robotics II

- Administration:
    - Prayer
    - Bible Verse
- **Hacksaws:**
    - Vertical and horizontal positions
    - Hacksaw blade must be positioned with the teeth pointing away from the handle. This will make it cut in the forward (push) stroke.
    - Make sure the frame is adjusted to proper length.
    - Start cut on flat side of work rather than on a corner or an edge. It is best to notch the work with a file, but a thumb can be used as a guide. Use enough pressure so that the blade will begin to cut immediately.
    - Make the cut by grasping the hacksaw frame by the handle and the front of the frame. Apply enough pressure on the forward stroke to make the teeth cut. Lift the saw slightly on the return stroke. Cut the full length of the blade about 40-50 strokes per minute.
    - If you start cutting with an old blade and it breaks, do not continue in the same cut with a new blade. Rotate work and start a new cut on the other side.
    - Support the stock being cut off with your free hand to prevent it from dropping where the cut is completed.
    - Use large tooth saw blades for large solid work and smaller tooth blades for angle iron, pipe, tubing and conduit.
    - Hacksaw Safety:
        - Never test the sharpness of a blade by running your fingers across the teeth.
        - Store saws in a way that will prevent you from accidentally grasping the teeth when you pick up a saw.
        - Burrs formed on the cut edge of metal are sharp and can cause a serious cut. Do not brush away chips with your hand; use a brush.
        - Always wear safety goggles while using a hacksaw. All hard blades can shatter and produce flying chips.
        - Be sure the hacksaw blade is properly tensioned. If it should break while you are on the cutting stroke, your hand may strike the work, causing a painful injury.
- **Files:**
    - A file is used for hand smoothing and shaping operations.
    - Files are made of high-grade carbon steel and are heat-treated to provide the necessary hardness and toughness.
    - File tang: a projecting point on a file that fits into a handle.
    - The hole of the handle should equal in diameter the width of the tang the midpoint.
    - Storing files
    - Cleaning with a file card.
    - General classifications of files: file length, type, and cut.
    - How to measure a file.
    - File type refers to shape and relative coarseness. Shapes can be flat, square, 3-square, half-round, and round.
    - Cut refers to single-cut, double-cut, rasp, and curved-tooth.

- Using a file.
  - Hold work at about elbow height.
  - Straight or cross filing consists of pushing the file lengthwise across the work, either straight ahead or at a slight angle.
  - Apply just enough pressure to permit the file to cut on the entire forward stroke. Lift the file from the work on the return stroke.
- File Safety:
  - Never use a file without a handle. Painful injuries may result!
  - Clean files with a file card, not your hand. The chips can penetrate your skin and result in a painful infection.
  - Do not clean a file by slapping it on the bench, since it may shatter.
  - Files are very brittle. Never use one for prying tasks.
  - Use a piece of cloth, not your bare hand, to clean the surface being filed. Sharp burrs are formed in filing and can cause serious cuts.
  - Never hammer on a file nor hammer with a file. It can shatter, causing chips to fly in all directions.

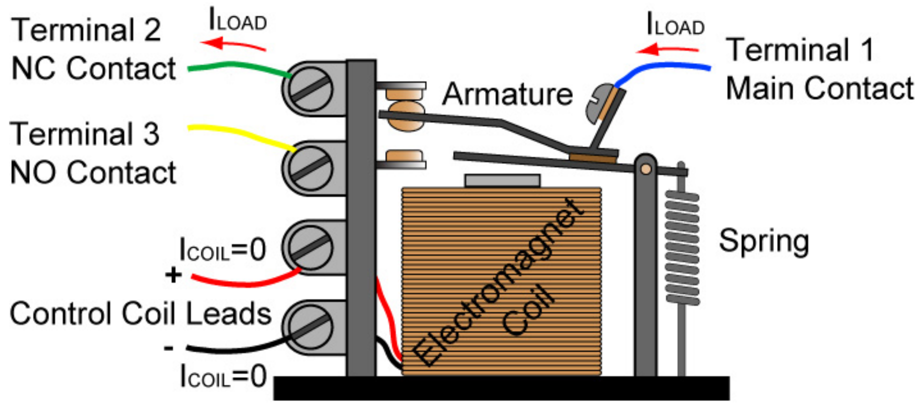
- **Review:**
  - Transistors:
    - Amplification: A small current through the base controls a large current through the collector and emitter.



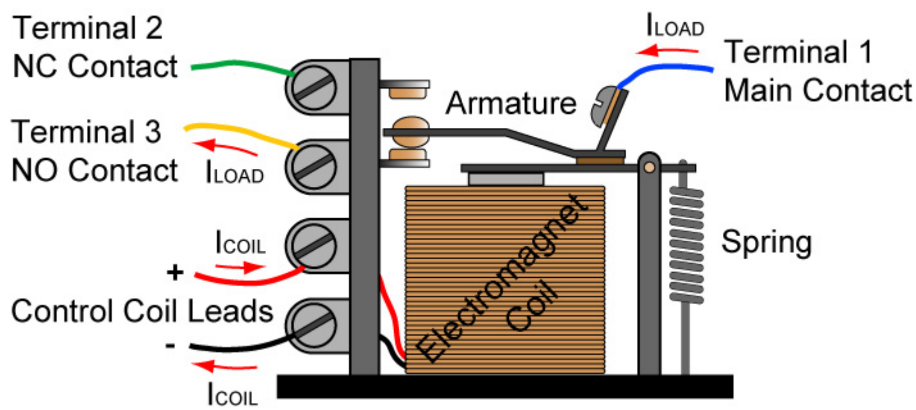
A very small base current can control a large collector current

- Perform Review 2 Lab 1 – NPN and PNP Transistor Switches
- Perform Review 2 Lab 2 – NPN Transistor Switch Application

- Relays:
  - General: A relay is a device that is used to control a large voltage, large current circuit by means of a low voltage, low current circuit. A relay is a magnetized switch that uses a mechanical lever to electrically separate two interactive circuits.
  - Mechanical action and electrical circuit interaction:

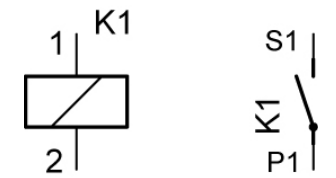


De-energized SPDT Relay – Spring Holds Armature in Position
Continuity from Terminal 1 (Main Contact) to Terminal 2 (NC Contact)

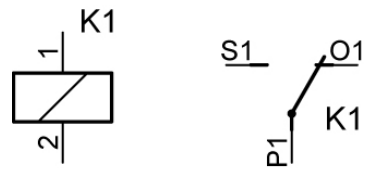


Energized SPDT Relay – Electromagnet Pulls Armature into Other Position
Continuity from Terminal 1 (Main Contact) to Terminal 3 (NO Contact)

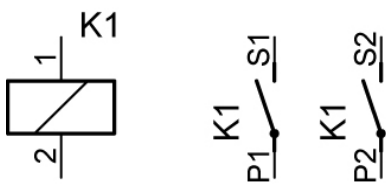
- Schematic Symbols:



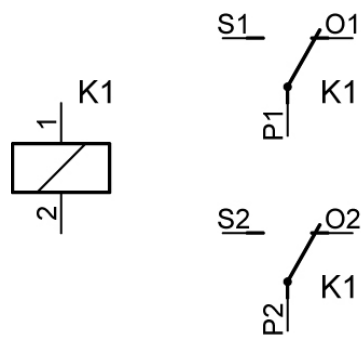
SPST



SPDT

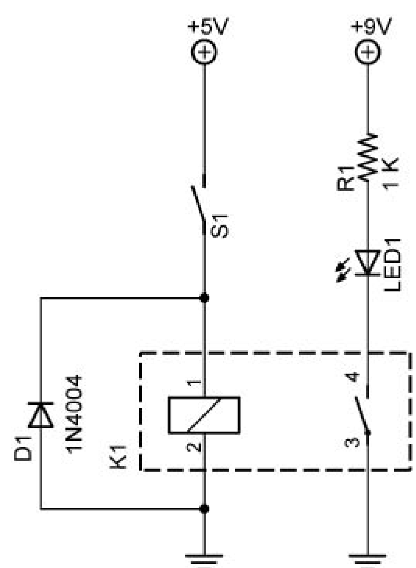


DPST



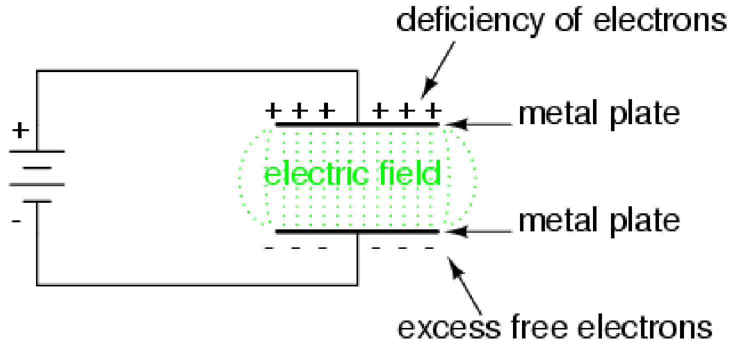
DPDT

- The two different voltages can be connected mechanically by a relay. The two circuits below are not connected electrically.



Relay Circuits Can Separate Two Voltages

- Capacitance:
  - Capacitors: A capacitor is made of two conductors that are separated by an insulator called a dielectric.
  - Important Characteristics of a Capacitor:
    - Capacitance is a property that opposes any change in voltage. See voltage changes in the RC section.
    - Unlike a resistor, a capacitor does not dissipate energy; instead a capacitor stores energy in an electric field.



From http://www.allaboutcircuits.com/vol_1/chpt_13/1.html

  - The value of a capacitor is dependent upon:
    - The area of the plates (directly related)

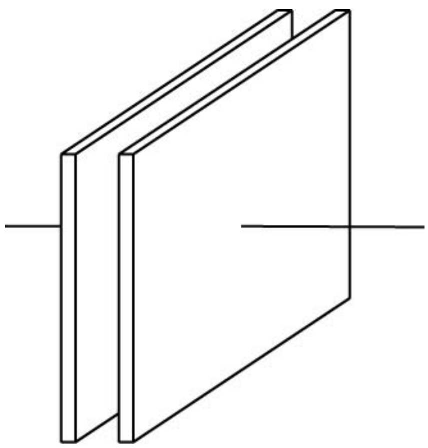


Figure 30 – 2a More Area – More Capacitance

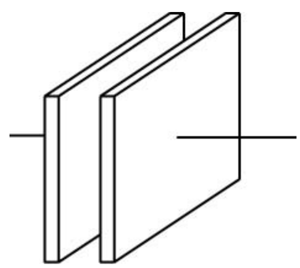


Figure 30 – 2b Less Area – Less Capacitance

    - The thickness T of the dielectric (inversely related):

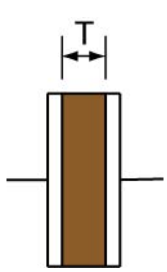


Figure 30 – 3a Less Thickness – More Capacitance

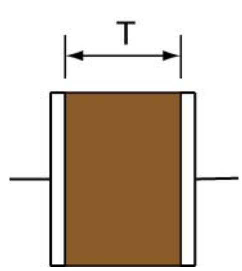
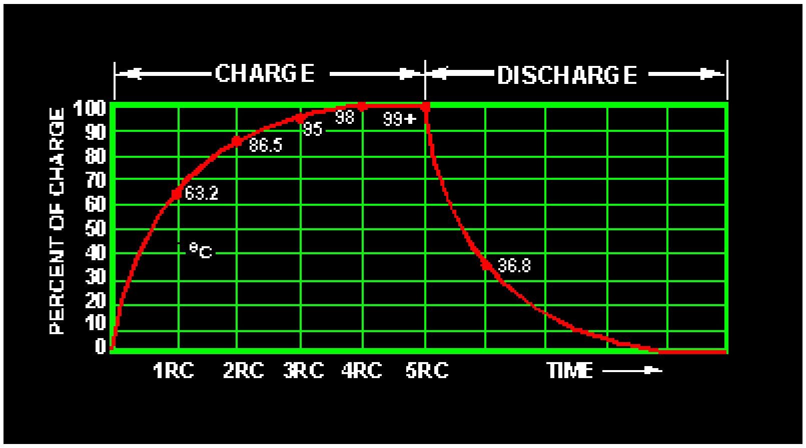


Figure 30 – 3b More Thickness – Less Capacitance

- The charge and discharge curves look as follows:



From: http://www.tpub.com/neets/book2/3d.htm

- The time it takes to charge the capacitor to 63.2% of its full charge is called the time constant (τ).

$$\tau = R\,C$$

Where:

τ = time constant, in seconds
R = resistance, in ohms, and
C = capacitance, in farads

- Our Use:
  - Timing circuits
  - Power supply circuits
  - Voltage regulator circuits
- Time Constants and % Charge and Discharge:

Time Constant τ = R C	**% Charge**	**% Discharge**
1	63.2	63.2
2	86.6	86.6
3	95	95
4	98	98
5	99	99

- Perform Review 2 Lab 3 – Charging and Discharging a Capacitor through a Resistor.

- **Tap and Drill Bit Sizes:**
    - Review the attached charts
    - Tap Chart:
        - 6-32 Refers to a #6 screw with 32 threads per inch
        - Choose the size screw and threads per inch, then look up the drill size on the chart
        - Demonstrate tapping
    - Drill Bit Size Chart:
        - Drill bit sizes come in numbered series (1-80), lettered series (A-Z) and fractional series (1/64-), all of which overlap each other.
        - Choosing a drill bit size for a particular screw
            - Use a vernier caliper to measure the screw diameter
            - Select drill bit size larger than the screw diameter
- **Shop Rules:**
    - Abide by all safety rules as we learn them, especially
        - Wear safety glasses around shop activity
        - Do not interrupt anyone that is using a power tool
        - Always ask Mr. Knack if you may use a power tool before turning on the tool.
    - Put tools, drill bits, and cutting tools back where they belong
    - Label your work and place in your plastic bin at the end of the class
    - Stationary power tools, workbenches, and floors are vacuumed at the end of each session. This duty will be rotated each week.
- **Survey of Shop Tool Locations**
- **Begin to Design and Fabricate Your Robotic Car (Approximately 40 min)**
- **Shop Cleanup (5 min)**

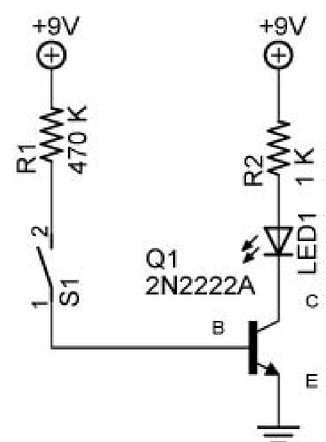
Electronics Technology and Robotics II Week 2
Electronics Review 2 Lab 1 – NPN and PNP Transistor Switches

- **Purpose:** The purpose of this lab is to demonstrate that a small base current controls a large collector/emitter current.

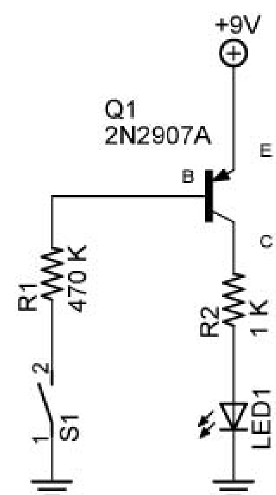
- **Apparatus and Materials:**

    - 1 – Solderless Breadboard with 9 V Power Supply
    - 2 – Digital Multimeters
    - 1 – 2N2907A PNP Transistor
    - 1 – 2N2222A NPN Transistor
    - 1 – SPST Switch
    - 1 – 470 K Ω Resistor
    - 1 – 1 K Ω Resistor
    - 1 – LED

- **Procedure:**
    - Build these NPN and PNP transistor test circuits.
    - Using the two multimeters, simultaneously measure the collector and base currents. Record the results.
    - Calculate the amplification factor (β) for each type of resistor.



NPN Transistor Switch



PNP Transistor Switch

- **Results:**

	Current (mA)	Amplification = I_C / I_B
NPN Circuit		
Collector		
Base		
PNP Circuit		
Collector		
Base		

- **Conclusion:**
  - Did your results verify that a very small current to the base can control a larger current that flows through the collector/emitter leads?

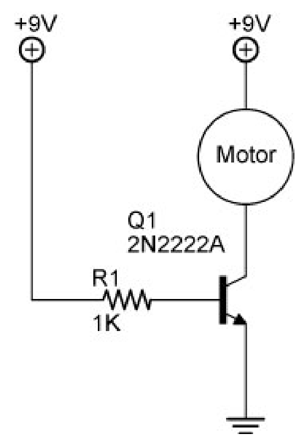
Electronics Technology and Robotics II Week 2
Electronics Review 2 Lab 2 – NPN Transistor Switch Application

- **Purpose:** The purpose of this lab is to demonstrate that a small base current controls a large collector/emitter current.

- **Apparatus and Materials:**

  - 1 – Solderless Breadboard with 9 V Power Supply
  - 1 – Gearhead Motor
  - 1 – 1K Ω Resistor
  - 1 – 2N2222A NPN Transistor

- **Procedure:**
  - Wire the following circuit.
  - Measure the currents in the base and the collector and record.
  - Calculate the amplification.

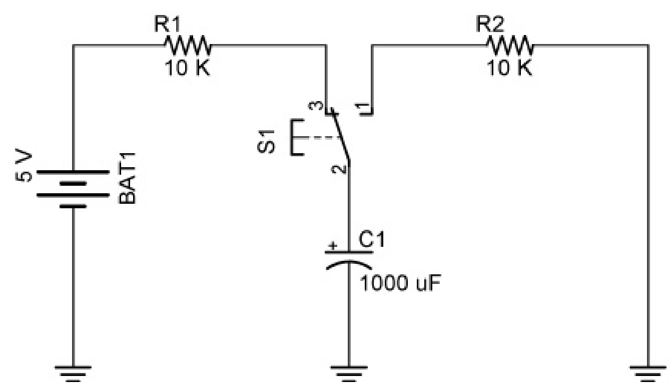


- **Results:**

	Current (mA)	Amplification = I_C / I_B
NPN Circuit		
Collector		
Base		

Electronics Technology and Robotics II Week 2
Review 2 Lab 3 – Charging and Discharging a Capacitor through a Resistor

- **Purpose:** The purpose of this lab is to verify the formula for the time constant, τ.
- **Apparatus and Materials:**
    - 1 – Breadboard with a 5 VDC Power Source
    - 2 – Digital Multimeters
    - 1 – Oscilloscope
    - 1 – Stop Watch
    - 2 – 10 K Resistors
    - 2 – 22 K Resistors
    - 1 – SPDT Switch
    - 1 – 1000 uF Capacitor
- **Procedure:**
    - Build the following circuit and place a voltmeter across the capacitor C1 and an ammeter between S1 and C1.
    - Qualitative Results:
        - Slide the switch toward the battery to charge the capacitor through resistor R1, and then slide the switch to the other position to discharge the capacitor through resistor R2.
        - Observe the voltage across and the current through the capacitor while switching back and forth. Record your observations.



$\tau = R\,C$

$\tau = 10.0 \times 10^{3}$ ohms $\times 1.0 \times 10^{-3}$ farads

$\tau = 10$ sec

Charging and Discharging a Capacitor through a Series Resistor

- Quantitative Results:
    - Measure and record the voltage across the power source.
    - Calculate and record 63.2% of the source voltage.
    - Measure and record the time in seconds it takes the capacitor to charge to 63.2 % of the source voltage (the definition of the time constant, τ).
    - Charge the capacitor until it is fully charged to the source voltage.
    - Subtract 63.2% of the source voltage from the value of the source voltage and record the result.
    - Measure and record the time in seconds it takes the capacitor to lose 63.2 % of its full charge (the definition of the time constant, τ).

- Replace the 2 – 10 K resistors with the 2 – 22 K resistors and repeat the Quantitative Results procedure used for the 10 K resistors.

- **Results:**
  - Qualitative Results:
    - When charging the capacitor, how does the voltage increase across the capacitor change with time?
    - When charging the capacitor, how does the current decrease through the capacitor change with time?
    - When discharging the capacitor, how does the voltage decrease across the capacitor change with time?
    - When discharging the capacitor, how does the current decrease through the capacitor change with time?
  - Quantitative Results:

Measurement	10 K Circuit	22 K Circuit
Power Source Voltage	V	V
63.2% of Power Source Voltage	V	V
Calculated Time to Charge 63.2% of Power Source Voltage	sec	sec
Measured Time to Charge 63.2% of Power Source Voltage	sec	sec
Power Source Voltage - 63.2% of Power Source Voltage	V	V
Calculated Time to Loose 63.2% of the Full Charge	sec	sec
Measured Time to Loose 63.2% of the Full Charge	sec	sec

- **Conclusions:**
  - Compare the calculated and measured times for the capacitor to charge to 63.2% of the power source (the time constant, τ). If the two values are not equal, explain the discrepancy.
  - Compare the calculated and measured times for the capacitor to discharge to 63.2% of the power source (the time constant, τ). If the two values are not equal, explain the discrepancy.

TAP / DRILL SIZES

American Std. and Unified Form Threads

Tap Drill Size is approximately 75% Thread

THREAD NOMINAL SIZE	Pitch Series	DRILL SIZE	DRILL DECIMAL	THREAD NOMINAL SIZE	Pitch Series	DRILL SIZE	DRILL DECIMAL
0-80	NF	3/64	.047	9/16-12	NC-UNC	31/64	.484
1-64	NC	53	.060	18	NF-UNF	33/64	.516
72	NF	53	.060	5/8-11	NC-UNC	17/32	.531
2-56	NC	50	.070	18	NF-UNF	37/64	.578
64	NF	50	.070	3/4-10	NC-UNC	21/32	.656
3-48	NC	47	.079	16	NF-UNF	11/16	.688
56	NF	45	.082	7/8-9	NC-UNC	49/64	.766
4-40	NC-UNC	43	.089	14	NF-UNF	13/16	.813
48	NF	42	.094	1-8	NC-UNC	7/8	.875
5-40	NC	38	.102	14	NS	15/16	.938
44	NF	37	.104	1 1/8-7	NC-UNC	63/64	.984
6-32	NC-UNC	36	.107	12	NF-UNF	1 3/64	1.047
40	NF	33	.113	1 1/4-7	NC-UNC	1 7/64	1.109
8-32	NC-UNC	29	.136	12	NF-UNF	1 11/64	1.172
36	NF	29	.136	1 3/8-6	NC-UNC	1 7/32	1.219
10-24	NC-UNC	25	.150	12	NF-UNF	1 19/64	1.297
32	NF-UNF	21	.159	1 1/2-6	NC-UNC	1 11/32	1.344
12-24	NC	16	.177	12	NF-UNF	1 27/64	1.422
28	NF	14	.182	1 3/4-5	NC-UNC	1 9/16	1.563
1/4-20	NC-UNC	7	.201	2 4 1/2	NC-UNC	1 25/32	1.781
28	NF-UNF	3	.213	2 1/4-4 1/2	NC-UNC	2 1/32	2.031
5/16-18	NC-UNC	F	.257	2 1/2-4	NC-UNC	2 1/4	2.250
24	NF-UNF	I	.272	2 3/4-4	NC-UNC	2 1/2	2.500
3/8-16	NC-UNC	5/16	.313	3-4	NC-UNC	2 3/4	2.750
24	NF-UNF	Q	.332	3 1/4-4	NC-UNC	3	3.000
7/16-14	NC-UNC	U	.368	3 1/4-4	NC-UNC	3 1/4	3.250
20	NF-UNF	25/64	.391	3 3/4-4	NC-UNC	3 1/2	3.500
1/2-13	NC-UNC	27/64	.422	4-4	NC-UNC	3 3/4	3.750
20	NF-UNF	29/64	.453				

*TAPER PIPE

THREAD	DRILL
1/16	D
1/8	R
1/4	7/16
3/8	37/64
1/2	45/64
3/4	59/64
1	1 5/32
1 1/4	1 1/2

*TAPER PIPE

THREAD	DRILL
1 1/2	1 47/64
2	2 7/32
2 1/2	2 5/8
3	3 1/4
3 1/2	3 3/4
4	4 1/4

*For tapping without reaming

STRAIGHT PIPE

THREAD	DRILL
1/16	1/4
1/8	11/32
1/4	7/16
3/8	37/64
1/2	23/32
3/4	59/64
1	1 5/32
1 1/4	1 1/2
1 1/2	1 3/4
2	2 7/32
2 1/2	2 21/32

METRIC THREADS

French and International Standard (D.I.N.)

TAP SIZE	STD.	DRILL STD.	DRILL DC.
2.5-.45	French	5/64	.0781
2.6-.45	D.I.N.	#45	.082
3-.50	D.I.N.	#39	.0995
.60	French	3/32	.0937
.75	Optional	#43	.089
3.5-.60	French & D.I.N.	#33	.113
4-.70	D.I.N.	#30	.1285
-.75	French	1/8	.125
4.5-.75	French & D.I.N.	#26	.147
5-.75	Optional	#19	.166
.80	D.I.N.	#19	.166
.90	French	#20	.161
1.00	Optional	5/32*	.156
5.5-.75	Optional	3/16	.1875
.90	French & D.I.N.	#14	.182
6-1.00	French & D.I.N.	#9	.196
1.25	Optional	3/16	.1875
7-1.00	French & D.I.N.	15/64	.234
1.25	Optional	#1	.228
8-1.00	French	J	.277
1.25	D.I.N.	17/64	.265
9-1.00	French	5/16	.3125
1.25	D.I.N.	5/16	.3125
10-1.00	Optional	23/64	.359
1.25	Optional	11/32	.3437
1.50	French & D.I.N.	R	.339
11-1.50	D.I.N.	3/8	.375
12-1.25	Optional	7/16	.4375
1.50	French	13/32	.406
1.75	D.I.N.	13/32	.406
13-1.50	Optional	29/64	.453
1.75	Optional	29/64	.453
2.00	Optional	7/16	.4375
14-1.25	Optional	33/64	.5156
1.75	Optional	1/2	.500
2.00	French & D.I.N.	15/32	.4687
15-1.75	Optional	17/32	.531
2.00	Optional	33/64	.5156
16-2.00	French & D.I.N.	35/64	.5468
17-2.00	Optional	19/32	.5937
18-1.50	Optional	21/32	.656
1/8-28	BSP	21/64	.3281

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DECIMAL AND METRIC EQUIVALENTS OF DRILL SIZES

DRILL SIZE	MM	DECIMAL INCHES	DRILL SIZE	MM	DECIMAL INCHES	DRILL SIZE	MM	DECIMAL INCHES
—	0.10	.0039	—	3.00	.1181	R	8.61	.3390
—	0.20	.0079	31	3.05	.1200	11/32	8.73	.3438
—	0.25	.0098	1/8	3.18	.1250	S	8.84	.3480
—	0.30	.0118	30	3.26	.1285	—	9.00	.3543
80	0.34	.0135	29	3.45	.1360	T	9.09	.3580
79	0.37	.0145	28	3.57	.1405	23/64	9.13	.3594
1/64	0.40	.0156	9/64	3.57	.1406	U	9.35	.3680
78	0.41	.0160	27	3.66	.1440	3/8	9.53	.3750
77	0.46	.0180	26	3.73	.1470	V	9.56	.3770
—	.050	.0197	25	3.80	.1495	W	9.80	.3860
76	0.51	.0200	24	3.86	.1520	25/64	9.92	.3906
75	0.53	.0210	23	3.91	.1540	—	10.00	.3937
74	0.57	.0225	5/32	3.97	.1562	X	10.08	.3970
—	0.60	.0236	22	3.99	.1570	Y	10.26	.4040
73	0.61	.0240	—	4.00	.1575	13/32	10.32	.4062
72	0.64	.0250	21	4.04	.1590	Z	10.49	.4130
71	0.66	.0260	20	4.09	.1610	27/64	10.72	.4219
—	0.70	.0276	19	4.22	.1660	—	11.00	.4331
70	0.71	.0280	18	4.31	.1695	7/16	11.11	.4375
69	0.74	.0292	11/64	4.37	.1719	29/64	11.51	.4531
—	0.75	.0295	17	4.39	.1730	15/32	11.91	.4688
68	0.79	.0310	16	4.50	.1770	—	12.00	.4724
1/32	0.79	.0313	15	4.57	.1800	31/64	12.30	.4844
—	0.80	.0315	14	4.62	.1820	1/2	12.70	.5000
67	0.81	.0320	13	4.70	.1850	—	13.00	.5118
66	0.84	.0330	3/16	4.76	.1875	33/64	13.10	.5156
65	0.89	.0350	12	4.80	.1890	17/32	13.49	.5312
—	0.90	.0354	11	4.85	.1910	35/64	13.89	.5469
64	0.91	.0360	10	4.91	.1935	—	14.00	.5512
63	0.94	.0370	9	4.98	.1960	9/16	14.29	.5625
62	0.97	.0380	—	5.00	.1968	37/64	14.68	.5781
61	0.99	.0390	8	5.05	.1990	—	15.00	.5906
—	1.00	.0394	7	5.11	.2010	19/32	15.08	.5938
60	1.02	.0400	13/64	5.16	.2031	39/64	15.48	.6094
59	1.04	.0410	6	5.18	.2040	5/8	15.88	.6250
58	1.07	.0420	5	5.22	.2055	—	16.00	.6299
57	1.09	.0430	4	5.31	.2090	41/64	16.27	.6406
56	1.18	.0465	3	5.41	.2130	21/32	16.67	.6562
3/64	1.19	.0469	7/32	5.56	.2188	—	17.00	.6693
55	1.32	.0520	2	5.61	.2210	43/64	17.07	.6719
54	1.40	.0550	1	5.79	.2280	11/16	17.46	.6875
53	1.51	.0595	A	5.94	.2340	45/64	17.86	.7031
1/16	1.59	.0625	15/64	5.95	.2344	—	18.00	.7087
52	1.61	.0635	—	6.00	.2362	23/32	18.26	.7188
51	1.70	.0670	B	6.05	.2380	47/64	18.65	.7344
50	1.78	.0700	C	6.15	.2420	—	19.00	.7480
49	1.85	.0730	D	6.25	.2460	3/4	19.05	.7500
48	1.93	.0760	1/4	6.35	.2500	49/64	19.45	.7656
5/64	1.98	.0781	E	6.35	.2500	25/32	19.84	.7812
47	1.99	.0785	F	6.53	.2570	—	20.00	.7874
—	2.00	.0787	G	6.63	.2610	51/64	20.24	.7969
46	2.06	.0810	17/64	6.75	.2656	13/16	20.64	.8125
45	2.08	.0820	H	6.76	.2660	—	21.00	.8268
44	2.18	.0860	I	6.91	.2720	53/64	21.03	.8281
43	2.26	.0890	—	7.00	.2756	27/32	21.43	.8438
42	2.37	.0935	J	7.04	.2770	55/64	21.84	.8594
3/32	2.38	.0938	K	7.14	.2810	—	22.00	.8661
41	2.44	.0960	9/32	7.14	.2812	7/8	22.23	.8750
40	2.50	.0980	L	7.37	.2900	57/64	22.62	.8906
39	2.53	.0995	M	7.49	.2950	—	23.00	.9055
38	2.58	.1015	19/64	7.54	.2969	29/32	23.02	.9062
37	2.64	.1040	N	7.67	.3020	59/64	23.42	.9219
36	2.71	.1065	5/16	7.94	.3125	15/16	23.81	.9375
7/64	2.78	.1094	—	8.00	.3150	—	24.00	.9449
35	2.79	.1100	O	8.03	.3160	61/64	24.21	.9531
34	2.82	.1110	P	8.20	.3230	31/32	24.61	.9688
33	2.87	.1130	21/64	8.33	.3281	—	25.00	.9842
32	2.95	.1160	Q	8.43	.3320	63/64	25.00	.9844
						1"	25.40	1.0000

For exact decimal equivalent, multiply mm times .03937. For exact mm equivalent, multiply decimal times 25.4.