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ECE 522 - Homework 3

In [1]:
```
# Import Libraries
import numpy as np
import matplotlib.pyplot as plt
import electricpy as ep
from electricpy.constants import *
from tabulate import tabulate
```

Example: (Session 5, Handout C)

In [8]:

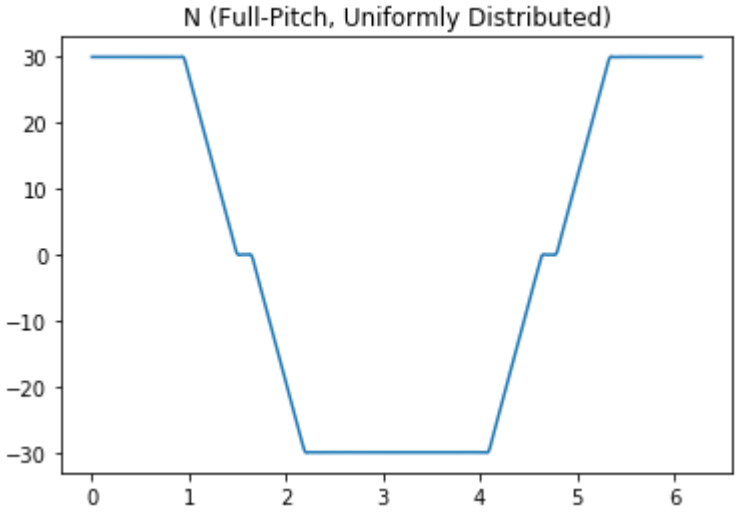
```
# Define Terms
Ncp = 60
Nslots = 18

# Define Sigma (Slot Pitch)
sigma = 2*np.pi/Nslots
print("Slot Pitch (sigma):",np.degrees(sigma),"°")

# Define Beta (Slot Opening)
beta = 0.5*sigma
print("Slot Opening (beta):",np.degrees(beta),"°")

# Define Coil Pitch
CPslots = 7
CPrad = CPslots*np.pi*2/Nslots
print("Coil Pitch (CPrad):",np.degrees(CPrad),"°")

# Define Gamma
gamma = np.pi - CPrad
print("Gamma:",round(np.degrees(gamma),2),"°")

# Define Harmonic Array
h = np.arange(1,102,2)
print("Harmonic Set:\n",h,"\n")

#########################################################################

# Evaluate F.S. Coefficient of Full Pitch Concentrated Coil Winding
ach = (2*Ncp) / (np.pi*h) * np.sin(h*np.pi/2)

# Evaluate Pitch Factor
kph = np.cos(h*(gamma/2))

# Distribution Factor
kdh = np.sinc(h*(beta/2))

#########################################################################

# Combine Terms to Evaluate ah
ah = kph * kdh * ach

# Evaluate Summation
data = np.array([])
for i, h_i in enumerate(h):
    row = [h_i, ah[i], kph[i], kdh[i], ach[i]]
    data = np.append(data, row)
data = np.around(np.reshape(data, (len(data)//5,5)),3)
print(tabulate(data,headers=['h', 'ah', 'kph', 'kdh', 'ach']))

#########################################################################

# Evaluate Terms for Plot
alpha = np.linspace(0,2*np.pi,1000)
NFuPCC = np.zeros(len(alpha))
for i, AH in enumerate(ah):
    NFuPCC += AH * np.cos(h[i]*alpha)
```

```
# Generate Plot
plt.plot(alpha,NFuPCC)
plt.title("N (Full-Pitch, Uniformly Distributed)")
plt.show()
```

```
Slot Pitch (sigma): 20.0 °
Slot Opening (beta): 10.0 °
Coil Pitch (CPrad): 140.0 °
Gamma: 40.0 °
Harmonic Set:
 [  1   3   5   7   9  11  13  15  17  19  21  23  25  27  29  31  33  35
  37  39  41  43  45  47  49  51  53  55  57  59  61  63  65  67  69  71
  73  75  77  79  81  83  85  87  89  91  93  95  97  99 101]
```

h	ah	kph	kdh	ach
1	35.446	0.94	0.988	38.197
3	-5.672	0.5	0.891	-12.732
5	-0.948	-0.174	0.715	7.639
7	2.047	-0.766	0.49	-5.457
9	-1.074	-1	0.253	4.244
11	0.111	-0.766	0.042	-3.472
13	0.059	-0.174	-0.115	2.938
15	0.256	0.5	-0.201	-2.546
17	-0.452	0.94	-0.214	2.247
19	0.319	0.94	-0.169	-2.01
21	-0.079	0.5	-0.087	1.819
23	0.001	-0.174	0.004	-1.661
25	-0.092	-0.766	0.079	1.528
27	0.172	-1	0.122	-1.415
29	-0.126	-0.766	0.125	1.317
31	0.02	-0.174	0.094	-1.232
33	0.024	0.5	0.041	1.157
35	0.018	0.94	-0.018	-1.091
37	-0.063	0.94	-0.065	1.032
39	0.044	0.5	-0.089	-0.979
41	0.014	-0.174	-0.086	0.932
43	-0.041	-0.766	-0.06	-0.888
45	0.016	-1	-0.018	0.849
47	0.015	-0.766	0.024	-0.813
49	-0.008	-0.174	0.057	0.78
51	-0.026	0.5	0.071	-0.749
53	0.043	0.94	0.064	0.721
55	-0.025	0.94	0.039	-0.694
57	0.002	0.5	0.005	0.67
59	-0.003	-0.174	-0.028	-0.647
61	0.024	-0.766	-0.051	0.626
63	-0.035	-1	-0.058	-0.606
65	0.022	-0.766	-0.048	0.588
67	-0.002	-0.174	-0.025	-0.57
69	0.001	0.5	0.004	0.554
71	-0.015	0.94	0.03	-0.538
73	0.023	0.94	0.046	0.523
75	-0.012	0.5	0.048	-0.509
77	-0.003	-0.174	0.037	0.496
79	0.006	-0.766	0.015	-0.484
81	0.005	-1	-0.01	0.472

83	-0.011	-0.766	-0.03	-0.46
85	0.003	-0.174	-0.041	0.449
87	0.009	0.5	-0.04	-0.439
89	-0.011	0.94	-0.027	0.429
91	0.003	0.94	-0.007	-0.42
93	0.003	0.5	0.014	0.411
95	0.002	-0.174	0.03	-0.402
97	-0.011	-0.766	0.037	0.394
99	0.013	-1	0.033	-0.386
101	-0.006	-0.766	0.02	0.378



Assignment Question:

Repeat the (above) example for a Fractional-Pitch, Concentrated-Coil winding.

In [12]:

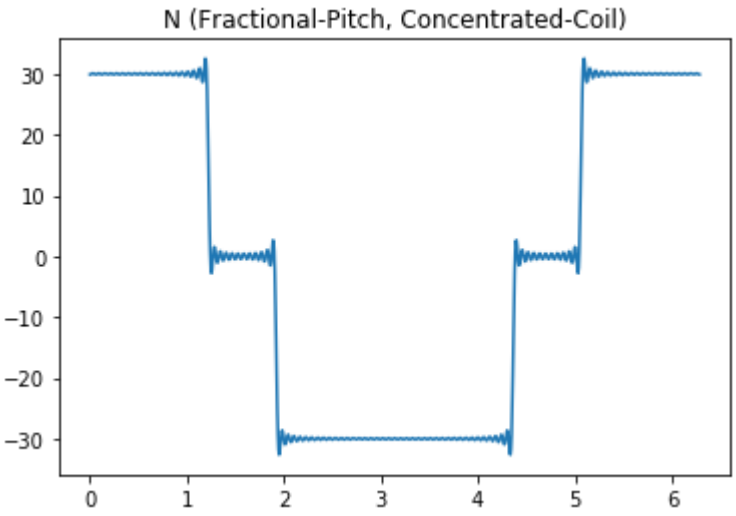
```
# Define Terms
Ncp = 60
Nslots = 18

# Define Sigma (Slot Pitch)
sigma = 2*np.pi/Nslots
print("Slot Pitch (sigma):",np.degrees(sigma),"°")

# Define Beta (Slot Opening)
beta = 0 # Concentrated Coil
print("Slot Opening (beta):",np.degrees(beta),"°")

# Define Coil Pitch
CPslots = 7
CPrad = CPslots*np.pi*2/Nslots
print("Coil Pitch (CPrad):",np.degrees(CPrad),"°")

# Define Gamma
gamma = np.pi - CPrad
print("Gamma:",round(np.degrees(gamma),2),"°")

# Define Harmonic Array
h = np.arange(1,102,2)
print("Harmonic Set:\n",h,"\n")

######################################################################

# Evaluate F.S. Coefficient of Full Pitch Concentrated Coil Winding
ach = (2*Ncp) / (np.pi*h) * np.sin(h*np.pi/2)

# Evaluate Pitch Factor
kph = np.cos(h*(gamma/2))

# Distribution Factor
kdh = np.sinc(h*(beta/2))

######################################################################

# Combine Terms to Evaluate ah
ah = kph * kdh * ach

# Evaluate Summation
data = np.array([])
for i, h_i in enumerate(h):
    row = [h_i, ah[i], kph[i], kdh[i], ach[i]]
    data = np.append(data, row)
data = np.around(np.reshape(data, (len(data)//5,5)),3)
print(tabulate(data,headers=['h', 'ah', 'kph', 'kdh', 'ach']))

######################################################################

# Evaluate Terms for Plot
alpha = np.linspace(0,2*np.pi,1000)
NFuPUD = np.zeros(len(alpha))
for i, AH in enumerate(ah):
    NFuPUD += AH * np.cos(h[i]*alpha)
```

```
# Generate Plot
plt.plot(alpha,NFuPUD)
plt.title("N (Fractional-Pitch, Concentrated-Coil)")
plt.show()
```

```
Slot Pitch (sigma): 20.0 °
Slot Opening (beta): 0.0 °
Coil Pitch (CPrad): 140.0 °
Gamma: 40.0 °
Harmonic Set:
 [  1   3   5   7   9  11  13  15  17  19  21  23  25  27  29  31  33  35
  37  39  41  43  45  47  49  51  53  55  57  59  61  63  65  67  69  71
  73  75  77  79  81  83  85  87  89  91  93  95  97  99 101]
```

h	ah	kph	kdh	ach
1	35.894	0.94	1	38.197
3	-6.366	0.5	1	-12.732
5	-1.327	-0.174	1	7.639
7	4.18	-0.766	1	-5.457
9	-4.244	-1	1	4.244
11	2.66	-0.766	1	-3.472
13	-0.51	-0.174	1	2.938
15	-1.273	0.5	1	-2.546
17	2.111	0.94	1	2.247
19	-1.889	0.94	1	-2.01
21	0.909	0.5	1	1.819
23	0.288	-0.174	1	-1.661
25	-1.17	-0.766	1	1.528
27	1.415	-1	1	-1.415
29	-1.009	-0.766	1	1.317
31	0.214	-0.174	1	-1.232
33	0.579	0.5	1	1.157
35	-1.026	0.94	1	-1.091
37	0.97	0.94	1	1.032
39	-0.49	0.5	1	-0.979
41	-0.162	-0.174	1	0.932
43	0.68	-0.766	1	-0.888
45	-0.849	-1	1	0.849
47	0.623	-0.766	1	-0.813
49	-0.135	-0.174	1	0.78
51	-0.374	0.5	1	-0.749
53	0.677	0.94	1	0.721
55	-0.653	0.94	1	-0.694
57	0.335	0.5	1	0.67
59	0.112	-0.174	1	-0.647
61	-0.48	-0.766	1	0.626
63	0.606	-1	1	-0.606
65	-0.45	-0.766	1	0.588
67	0.099	-0.174	1	-0.57
69	0.277	0.5	1	0.554
71	-0.506	0.94	1	-0.538
73	0.492	0.94	1	0.523
75	-0.255	0.5	1	-0.509
77	-0.086	-0.174	1	0.496
79	0.37	-0.766	1	-0.484
81	-0.472	-1	1	0.472
83	0.353	-0.766	1	-0.46

85	-0.078	-0.174	1	0.449
87	-0.22	0.5	1	-0.439
89	0.403	0.94	1	0.429
91	-0.394	0.94	1	-0.42
93	0.205	0.5	1	0.411
95	0.07	-0.174	1	-0.402
97	-0.302	-0.766	1	0.394
99	0.386	-1	1	-0.386
101	-0.29	-0.766	1	0.378



In [ ]:
```
1
```