Homework #4 -- Tuned Class B operation

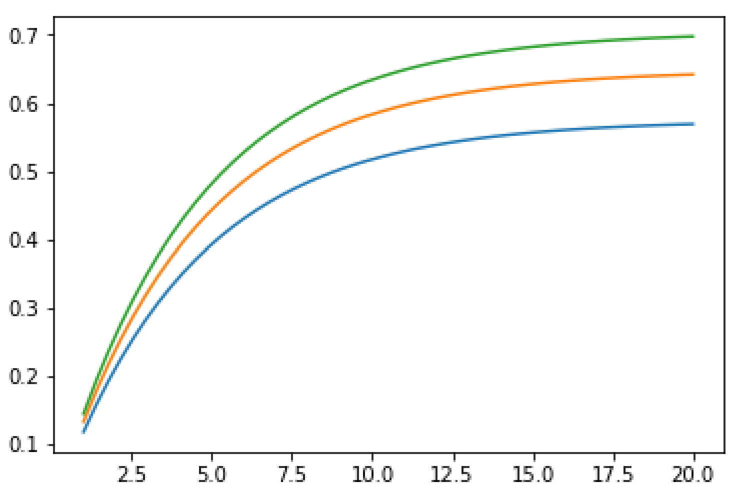
Part D

Assuming that: $\eta_{max} = \frac{P_{out} - P_{in}}{P_{dc}}$

For a tuned Class B amplifier: $\eta_{max} = \left(1 - \frac{1}{G}\right) * \frac{\pi(V_{br} - V_k)}{8V_s}$

In [6]:

```
import numpy as np
import matplotlib.pyplot as plt

#Initial Declaration of constants
Vk = 5
Vp = 3.5
VΦ = 0.7

GdB = np.linspace(1,20,50)
Vdgb = np.array([40,60,100])

# For Class B
#Breakdown voltage
def Vbr(Vdgb):
    return Vdgb - 2*abs(Vp) - VΦ

# Source voltage? changes whether it's class B resistive or tuned
def Vs(Vdgb):
    return (Vbr(Vdgb) + Vk)/2

#Efficiency Redone for Class B tuned
def Nmax(Vdgb,GdB):
    return (np.pi/8)*(1-1/(10**(GdB/10)))*(Vbr(Vdgb)-Vk)/(Vs(Vdgb))

for v in Vdgb:
    plt.plot(GdB,Nmax(v,GdB))
plt.show()
```

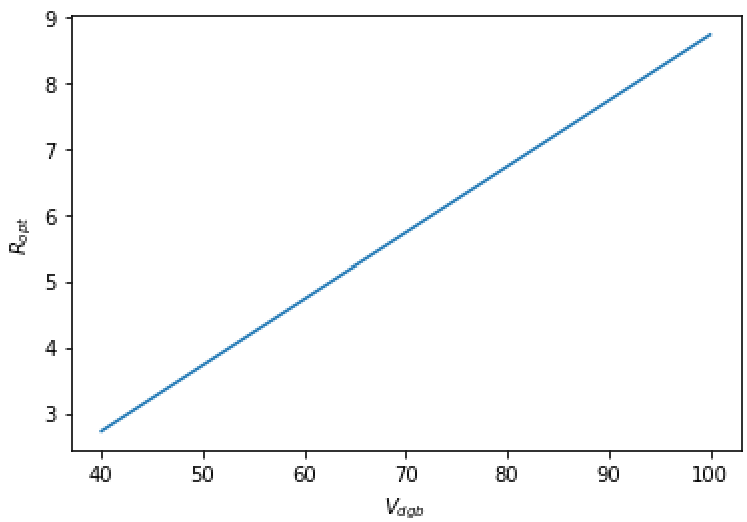


Part E

$R_{opt} = \frac{V_{br} - V_k}{I_F}$

In [2]:
```
If = 10

def Ropt(Vdgb):
    return (Vbr(Vdgb)-Vk)/If

for v in Vdgb:
    print("Vdgb = {} => R_opt = {}".format(v,Ropt(v)))

plt.plot(Vdgb,Ropt(Vdgb))
plt.ylabel("$R_{opt}$")
plt.xlabel("$V_{dgb}$")
plt.show()
```

```
Vdgb = 40 => R_opt = 2.7299999999999995
Vdgb = 60 => R_opt = 4.7299999999999995
Vdgb = 100 => R_opt = 8.73
```

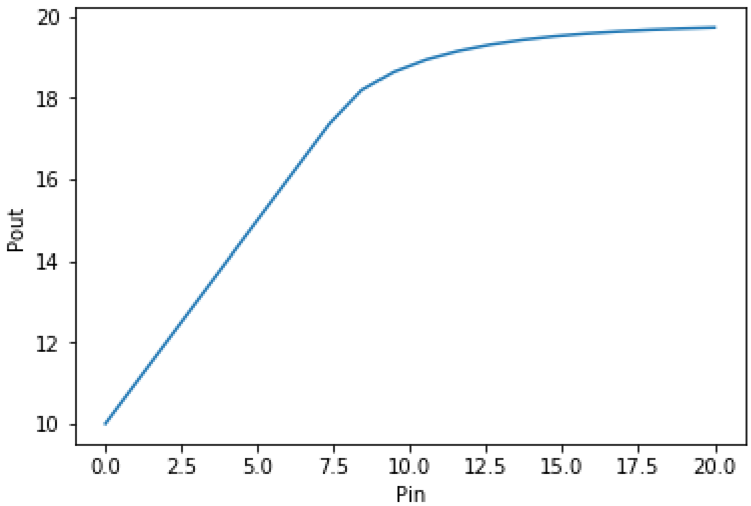


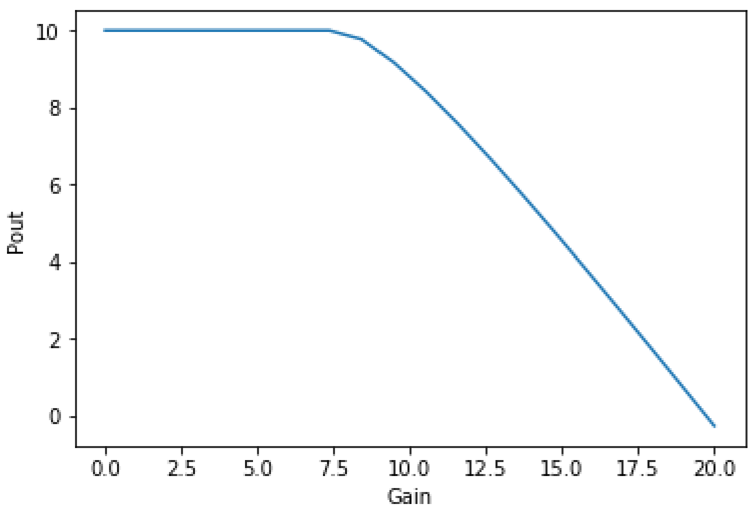
Part F: I

In [3]:

```
Pin = np.linspace(0,20,20)
Pin_lin = 10**(Pin/10)

GdB = 10
Glin = 10**(GdB/10)
Vdgb = 60

Pmax_lin = (Vbr(Vdgb)-Vk)*If/8
Pmax_in_lin = Pmax_lin/Glin
Pmax_in_lin_dB = 10*np.log10(Pmax_in_lin)

def z(Pin_lin):
    return np.sqrt(Pmax_in_lin/Pin_lin)

def f(Pin_lin):
    return (1-(2/np.pi)*np.arccos(z(Pin_lin))+(1/np.pi)*np.sin(2*np.arccos(z(P
in_lin))))**2

def Gnl(Pin_lin):
    return Glin*f(Pin_lin)

Pout_lin = np.where(Pin_lin<Pmax_in_lin,Pin_lin*GdB,Pin_lin*Gnl(Pin_lin))
Pout_dB = 10*np.log10(Pout_lin)

plt.plot(Pin,Pout_dB)
plt.xlabel("Pin")
plt.ylabel("Pout")
plt.show()

plt.plot(Pin,Pout_dB-Pin,label="Gain v.s. Pin")
plt.xlabel("Gain")
plt.ylabel("Pout")
plt.show()
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:16: RuntimeW
arning: invalid value encountered in arccos
  app.launch_new_instance()
```





Part F II: Derive an expression for PAE in the case of over driven class B operation

The definition of PAE is again: $\eta = \frac{P_{out}-P_{in}}{P_{dc}}$ in the non-linear case $\eta_{NL} = \frac{P_{out}-P_{in}}{P_{dc}}, P_{in} > P_{in,max}$ Expressing Pout in terms of Pin: $\eta_{NL} = \frac{(1+G\dot{f}(z))P_{in}}{P_{dc}}$ If we additionally assume that $P_{dc} = V_s * I_{pk}/\pi$ even into overdrive, then: $\eta_{NL} = \frac{(1+G\dot{f}(z))P_{in}}{V_s\dot{I}_{pk}/\pi}$

In [4]:

```
#Part F:III
# this function also assumes that Pdc scales with the square root of input pow
er
def eta(Pin_lin): #                     if nonlinear
       if linear
    nonlinear = (Gnl(Pin_lin)+1)*Pin_lin/(Vs(Vdgb)*If*np.sqrt(Pin_lin/Pmax_in_
lin)/np.pi)
    linear = (Glin+1)*Pin_lin/(Vs(Vdgb)*If*np.sqrt(Pin_lin/Pmax_in_lin)/np.pi)
    return np.where(Pin_lin>Pmax_in_lin,nonlinear,linear)

plt.plot(10*np.log10(Pin_lin),eta(Pin_lin))
plt.xlabel("Pin")
plt.ylabel("PAE")
plt.show()
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:16: RuntimeW
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```

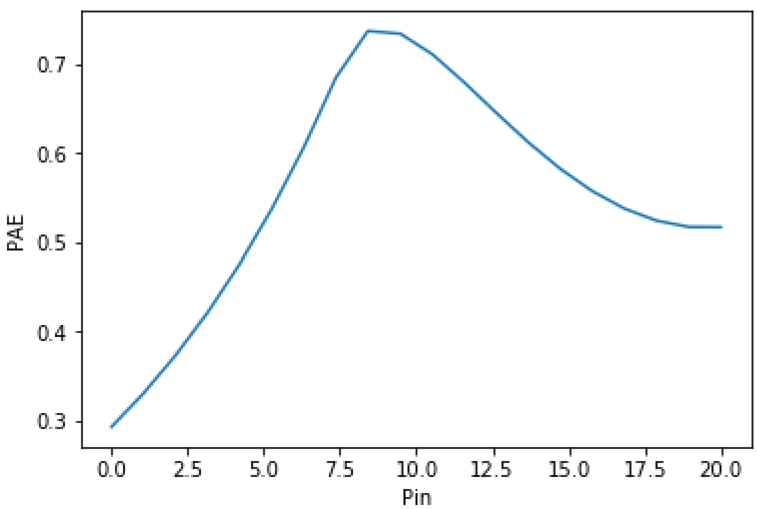

In [5]:

```
#Part F:IV
def Gain_complete(Pin_lin):
    nonlinear = Gnl(Pin_lin)
    linear = Glin
    return np.where(Pin_lin>Pmax_in_lin,nonlinear,linear)


gain_comp = Gain_complete(Pin_lin)/Glin
plt.plot(-10*np.log10(gain_comp),eta(Pin_lin))
plt.xlabel("Gain Compression")
plt.ylabel("PAE")
plt.show()
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:16: RuntimeW
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  app.launch_new_instance()
```

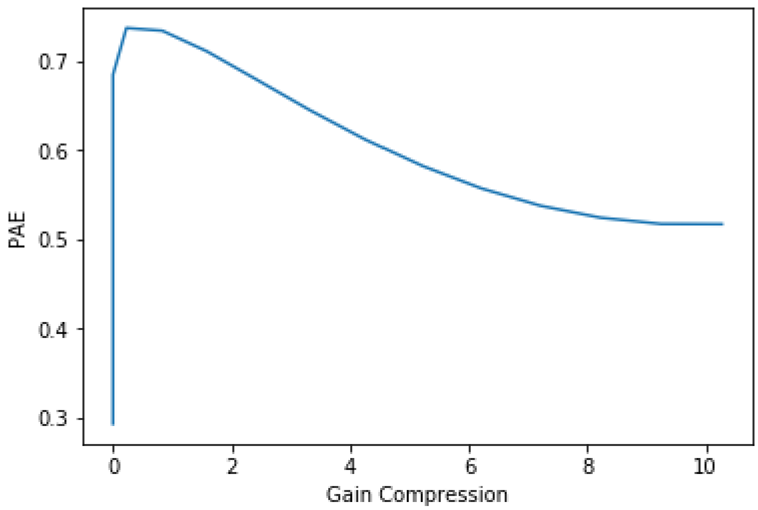

Part F: V From our previous plot in part C/I/, we can estimate P_{sat} to be 19.5 dBm

In [ ]: