Part1_1
Sheel Shah 19D070052

```
.include bc547a.txt

q0 0 1 2 bc547a
r2 3 2 100
i_source 0 1 0.1m
v_ce 3 0

.dc v_ce 0 4 0.01
.control
run

plot -i(v_ce) vs v(3)

.endc
.end
```

part1_2
Sheel Shah 19D070052

```
.include bc547a.txt

q0 0 1 2 bc547a
r2 3 2 100
i_source 0 1 0.1m
v_ce 3 0 3

.dc temp 25 55 10
.control
run

plot -i(v_ce)
print -i(v_ce)

.endc
.end
```

part1 _3
19D070052 Sheel Shah I_d vs V_ds

```
.include NMOSFET.txt

** 1 2 3 4: drain gate source body
m1 1 2 0 4 NMOSFET
v_dd 4 0 0
v_id 10 1 0
v_ds 10 0
v_gs 2 0 3


.dc v_ds 0 5 0.1

* start control
.control
set color0 = rgb:f/f/e
set color1 = rgb:1/1/1

run

plot i(v_id) vs v(10)

.endc

.end
```

part1_4
19D070052 Sheel Shah I_d vs V_ds

```
.include NMOSFET.txt

** 1 2 3 4: drain gate source body
m1 1 2 0 4 NMOSFET
v_dd 4 0 0
v_id 10 1 0
v_ds 10 0 3
v_gs 2 0 3


.dc temp 25 55 10

* start control
.control
set color0 = rgb:f/f/e
set color1 = rgb:1/1/1

run

plot i(v_id)

.endc

.end
```

part1_5
Sheel Shah 19D070052

```
.include bc547a.txt

q0 0 1 2 bc547a
r2 3 2 100
i_source 0 1 0.1m
v_ce 3 0 pulse(0 3 0 0 0 0.25u 1000)

.tran 1n 1u
.control
run

plot -i(v_ce)
** time = 1e-8

.endc
.end
```

```
part1_6
19D070052 Sheel Shah I_d vs V_ds

.include NMOSFET.txt

** 1 2 3 4: drain gate source body
m1 1 2 0 4 NMOSFET
v_dd 4 0 0
v_id 10 1 0
v_ds 10 0 pulse(0 5 0 0 0 0.25u 1000)
v_gs 2 0 3


.tran 1n 1u

* start control
.control
run

plot i(v_id)
** time = 2e-10

.endc

.end
```

part2_1
19D070052 Sheel Shah I_d vs V_ds

```
.include NMOSFET.txt

** 1 2 3 4: drain gate source body
m1 1 2 0 4 NMOSFET
v_dd 4 0 0
v_id 10 1 0
v_ds 10 0 0.3
v_gs 2 0


.dc v_gs 0.3 3.3 0.01

* start control
.control
run

plot (2 * i(v_id) / (2 * (v(2) - 0.5710859) * 0.3) / (450n * 3)) vs v(2)

.endc

.end
```

part2_2
19D070052 Sheel Shah I_d vs V_ds

```
.include NMOSFET.txt

** 1 2 3 4: drain gate source body
m1 1 2 0 4 NMOSFET
v_dd 4 0 0
v_id 10 1 0
v_ds 10 0 0.3
v_gs 2 0 1.5


.dc temp 20 80 10

* start control
.control
run

plot (2 * i(v_id) / (2 * (v(2) - 0.5710859) * 0.3) / (450n * 3))

.endc

.end
```

```
part2_3
19D070052 Sheel Shah I_d vs V_ds

.include NMOSFET.txt

** 1 2 3 4: drain gate source body
m1 1 2 0 4 NMOSFET
v_dd 4 0 0
v_id 10 1 0
v_ds 10 0 0.3
v_gs 2 0 0.6


.dc temp 20 80 10

* start control
.control
run

plot (2 * i(v_id) / (2 * (v(2) - 0.5710859) * 0.3) / (450n * 3))

.endc

.end
```

```
part2_4
19D070052 Sheel Shah I_d vs V_ds

.include NMOSFET.txt

** 1 2 3 4: drain gate source body
m1 1 2 0 4 NMOSFET W=30u L=0.4u
v_dd 4 0 0
v_id 10 1 0
v_ds 10 0 0.3
v_gs 2 0


.dc v_gs 0 3.3 0.01 temp 25 125 50

* start control
.control
run

plot log10(i(v_id)) vs v(2)

** ss: 25: 98.7, 75: 111.6, 125: 126.0 (mV/dec)
** off current: 6.3e-12, 6.3e-11, 3.2e-10

.endc

.end
```

```
part3_1
19D070052 Sheel Shah I_d vs V_ds

.include NMOSFET.txt

** 1 2 3 4: drain gate source body
m_short 11 2 0 4 NMOSFET W=1.2u L=0.2u
m_long 12 2 0 4 NMOSFET W=120u L=20u
v_dd 4 0 0
v_id1 10 11 0
v_id2 10 12 0
v_ds 10 0
v_gs 2 0 1.5


.dc v_ds 0 3.3 0.01

* start control
.control
run

plot i(v_id1), i(v_id2) vs v(10)

print i(v_id1), i(v_id2)

** ro: 41k, 1300k

.endc

.end
```

```
part3_2
19D070052 Sheel Shah I_d vs V_ds

.include NMOSFET.txt

** 1 2 3 4: drain gate source body
m_short 11 2 0 4 NMOSFET W=1.2u L=0.2u
m_long 12 2 0 4 NMOSFET W=120u L=20u
v_dd 4 0 0
v_id1 10 11 0
v_id2 10 12 0
v_ds 10 0 3
v_gs 2 0


.dc v_gs 0 3.3 0.01

* start control
.control
run

plot i(v_id1), i(v_id2) vs v(2)
plot log10(i(v_id1)), log10(i(v_id2)) vs v(2)

** v_th: 0.1V, 0.5V
** i_on: 1.47m, 2.45m
** ss: 166mV/dec, 104mV/dec
** i_off: 2e-6, 6.3e-12

** ro: 41k, 1300k

.endc

.end
```

```
part4_1
19D070052 Sheel Shah I_d vs V_ds
.include CMOS.txt


v_dd 1 0 3.3
v_in 2 0 pulse(0 3.3 0 20p 20p 280p 600p)
v_bb_p 10 0 3.3
v_bb_n 11 0 0

m_p 3 2 1 10 cmosp L=0.4u W=3.36u
m_n 3 2 0 11 cmosn L=0.4u W=1.3u
c0 3 4 0.05p
v_dummy 4 0 0

.tran 0.1p 5000p
.control
run
meas tran rise trig v(3) val=0.33 rise=1 targ v(3) val=2.97 rise=1
meas tran delay trig v(2) val=1.665 rise=2 targ v(3) val=1.665 fall=2
meas tran fall trig v(3) val=2.97 fall=1 targ v(3) val=0.33 fall=1

.endc
.end
```

```
part4_2
19D070052 Sheel Shah I_d vs V_ds
.include CMOS.txt


v_dd 1 0 3.3
v_in 2 0
v_bb_p 10 0 3.3
v_bb_n 11 0 0

m_p 3 2 1 10 cmosp L=0.4u W=3.36u
m_n 3 2 0 11 cmosn L=0.4u W=1.3u
c0 3 4 0.05p
v_dummy 4 0 0

.dc v_in 0 3.3 0.01
.control
run
plot v(3), (-v(2)+2.25), (-v(2)+4.4) vs v(2)

** voh = 2.98
** vol = 0.24
** vih = 2.00
** vil = 1.42
** nmh = voh - vih = 0.98
** nml = vil - vol = 1.18

.endc
.end
```

```
part4_3
19D070052 Sheel Shah I_d vs V_ds
.include CMOS.txt


v_dd 1 0 3.3
v_in 2 0
v_bb_p 10 0 3.3
v_bb_n 11 0 0

m_p 3 2 1 10 cmosp L=0.4u W=3.36u
m_n 3 2 0 11 cmosn L=0.4u W=1.3u
c0 3 4 0.05p
v_dummy 4 0

.dc v_in 0 3.3 0.01
.control
run
plot i(v_dd) vs v(2)

** voh = 2.98
** vol = 0.24
** vih = 2.00
** vil = 1.42
** nmh = voh - vih = 0.98
** nml = vil - vol = 1.18

.endc
.end
```