TODAY'S LECTURE

For the project, you have an active filter that cannot supply the current (a few hundred mA) needed to power the mirror actuator. We'll therefore discuss power amplifiers today.

We'll also go over one way of generating frames for your laser light show animation.
AN "EMITTER FOLLOWER" — THE SIMPLEST CURRENT BOOSTER.  (SINGLE-ENDED, UNITY GAIN AMPLIFIER)

\[ V_{out} = V_{in} - 0.7V \]

So what?

\[ N'c = \beta \mu_b \]

So \( V_{cc} \) takes most of the load.

This is a Crude Voltage Follower.

It's just off by a bit.

Q: What are the limitations of this circuit?
I've added impedance of 1kΩ to the signal Vin. (Why else would we need a follower?)

Second circuit is PNP version:

\[ V_{out} = V_{in} + 0.7 \text{ V} \]
WHAT WE WOULD LIKE TO FIX:

- CUTOFF
- OFFSET
- LOADING
The Push-Pull.

Combine NPN and PNP single-ended amps. Can we reach both rails?

\[ V_2 \quad U=12 \text{ V} \]
\[ V_1 \quad U=V_{in} \]
\[ R_1 = 1k \]
\[ V_3 \quad U=12 \text{ V} \]

\[ T_1 \quad B_f=100 \]
\[ T_2 \quad B_f=100 \]
\[ V_{out} \]
\[ R_{load} \quad R=100 \]

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**dc simulation**
DC1

**Parameter sweep**

- SW1
- Sim=DC1
- Type=lin
- Param=Vin
- Start=-20V
- Stop=20V
- Points=401

**Equation**

- Eqn1
- ideal=Vin
The Push-Pull.

Unlike the single-ended amp, it can sink or source current and go to both rails.

Still shows effects of loading.

Still an offset problem due to cutoff near Vin = 0.
Diode Bias.

A popular way to fix the offsets. Diodes produce signals $V_{in} + 0.7V$ and $V_{in} - 0.7V$.

**dc simulation**

DC1

**Parameter sweep**

SW1
Sim=DC1
Type=lin
Param=Vin
Start=-20V
Stop=20V
Points=401

**Equation**
Eqn1
ideal=Vin
Diode Bias.

- Eliminates offset (provided the diode drop matches the BJT junction voltage).
- Worsens loading (larger bias resistors help)
- Can't reach rail-to-rail (smaller bias resistors help)
- If impedance on Vin is removed, the last 2 problems are fixed. But then we wouldn't need an amp at all!
I wondered whether I had missed something— is the diode biased push-pull really that bad? So I tried replicating the example discussed by H&H.

Diode Bias.

Modeled on the example described on P.92 of Horowitz & Hill (2ed).

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**dc simulation**

DC1

**Parameter sweep**

SW1
Sim=DC1
Type=lin
Param=Vin
Start=-30V
Stop=30V
Points=601

**Equation**

Eqn1
ideal=Vin

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I've again chosen an impedance that is 10x the rail.
Diode biased push-pull powers an 8Ω speaker. Parameters based on H&H p.92 (2ed).
Can negative feedback solve the issues with a push-pull?

```
V1
U=Vin

R1
R=1k

T1
Bf=100

V2
U=12 V

T2
Bf=100

V3
U=12 V

Vout

Rload
R=100
```

```
dc simulation
DC1

Parameter sweep
SW1
Sim=DC1
Type=lin
Param=Vin
Start=-20V
Stop=20V
Points=401

Equation
Eqn1
ideal=Vin
```
Push-pull controlled by op amp with negative feedback.

\[ V_{out} \text{ vs } V_{in} \]

**Q: What are the limitations of this circuit?**

*(Hint: what if \( V_{in} \) is changing rapidly as it crosses zero?)*