Analog Electronics - XXXIV

Lakshya GATE 2023: Course on Analog Electronics for ECE EE IN

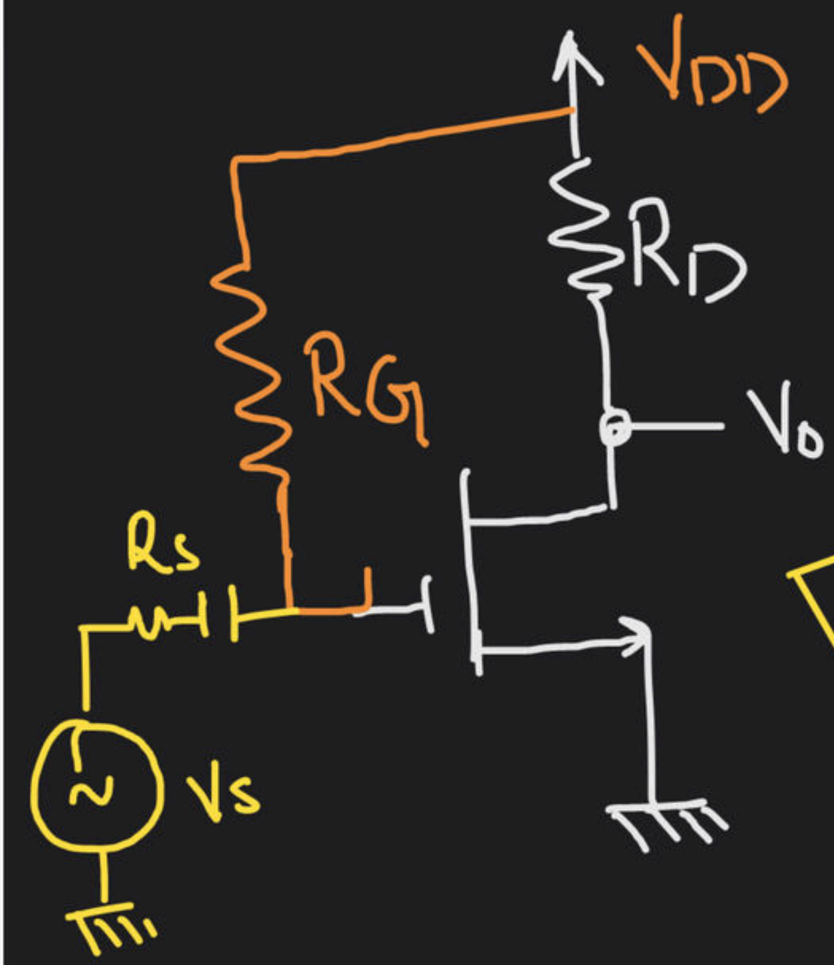
Siddharth Sabharwal • Lesson 45 • June 10, 2022


BE WITH PEOPLE WHO INSPIRE YOU.
AND MAKE SURE YOU INSPIRE THEM TO BECOME STRONGER AND BETTER.
Friends

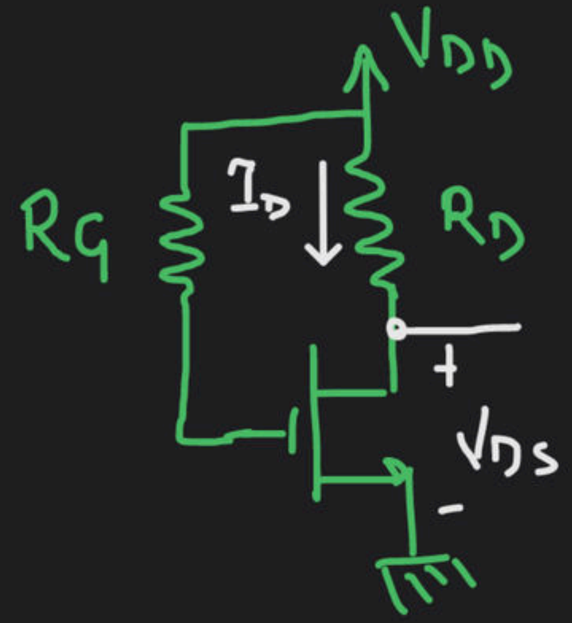
Topic :- Ac and Dc load line

⇒ The Bias point of Mosfet $\{I_D, V_{DS}\}$,

Example



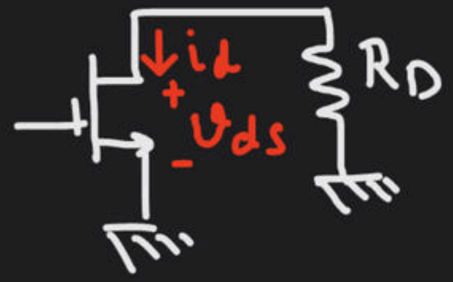
dc Analysis



dc load line

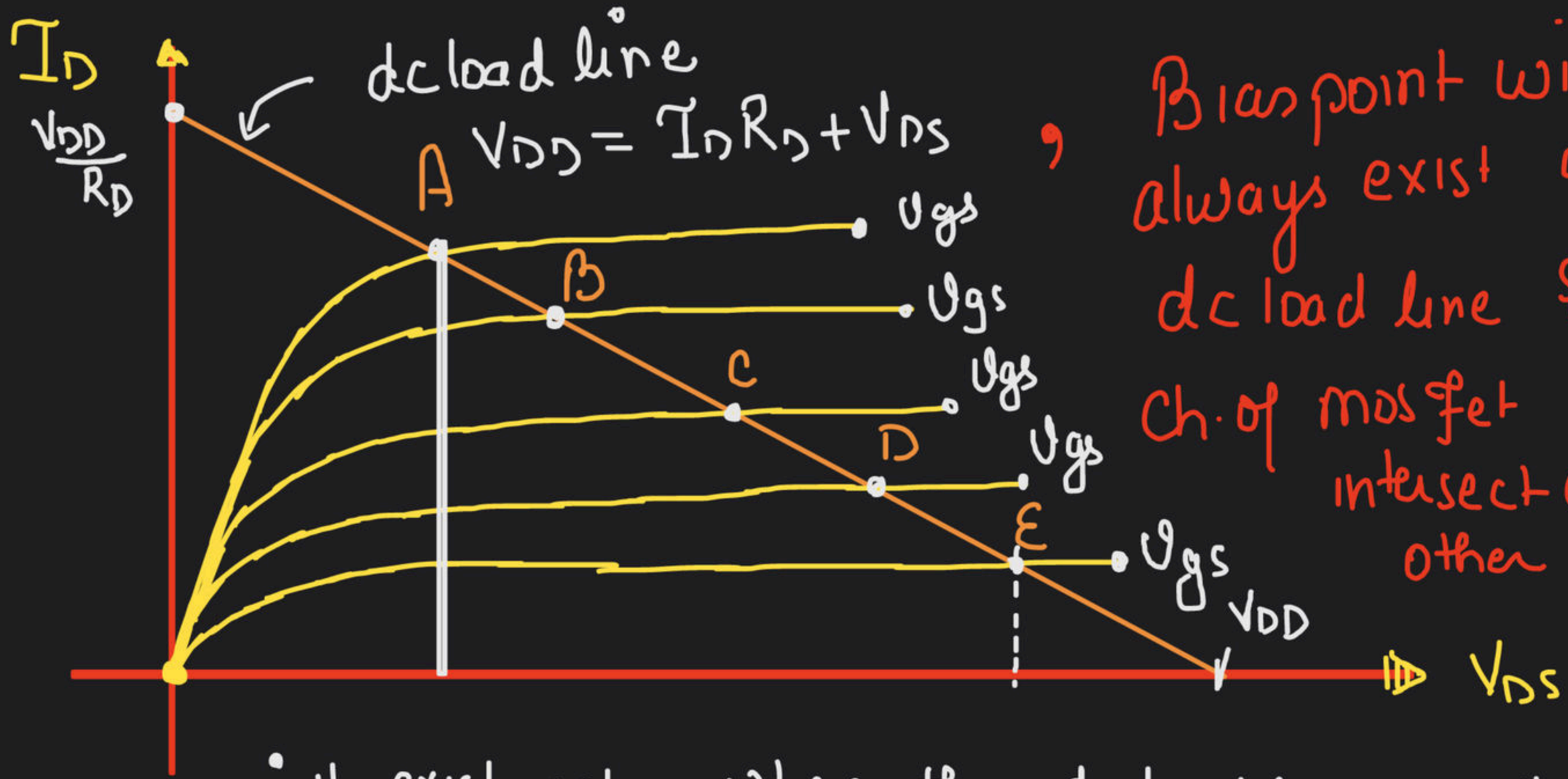
$$V_{DD} = I_D R_D + V_{DS}$$

Ac Analysis ckt



$$v_{ds} = -i_d R_D$$

ac load line

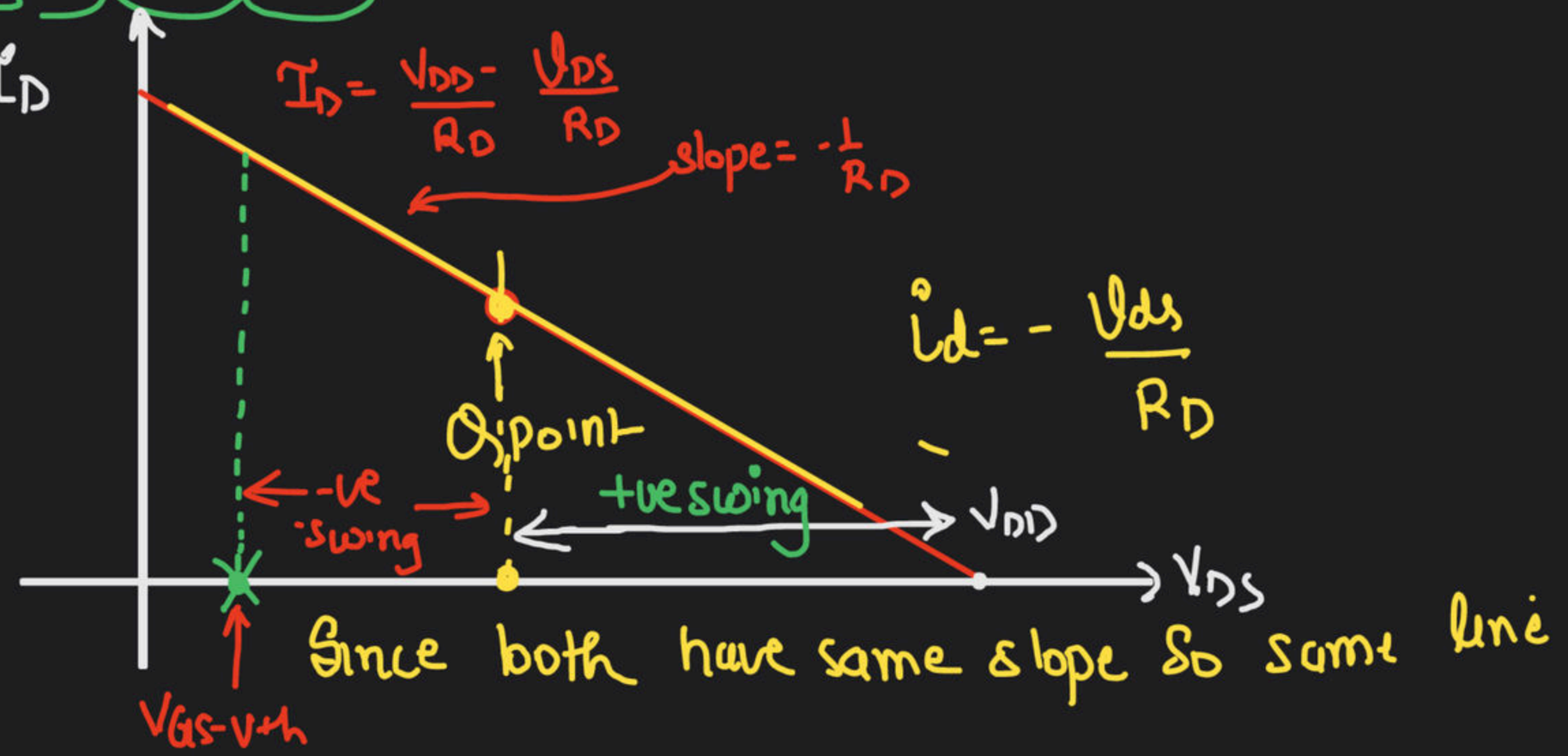


Bias point will always exist where dc load line & Ch. of mosfet intersect each other

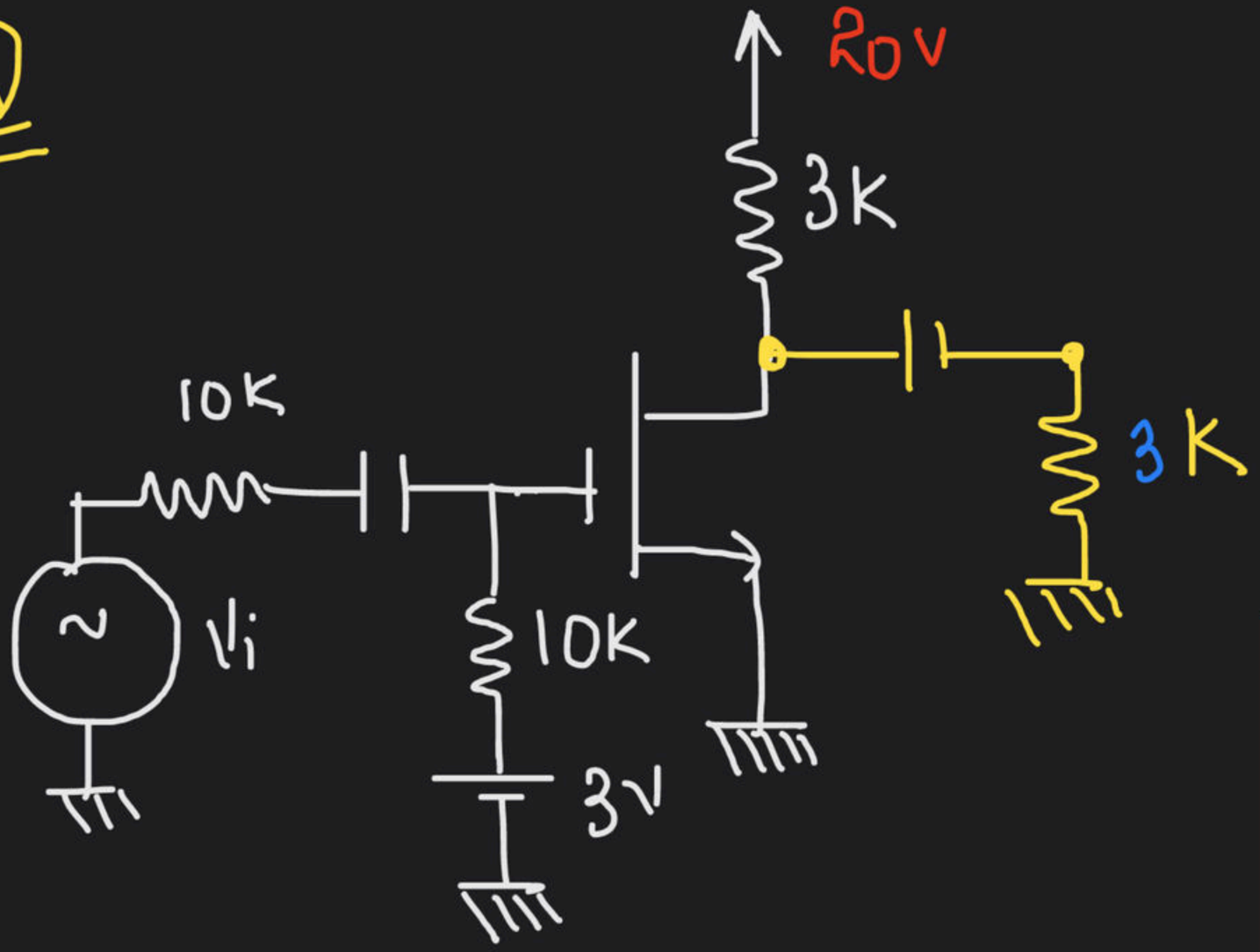
The bias point will exist only where the dc load line i.e KVL and mosfet ch. are satisfied i.e they both cut each other

We always bias the device @ middle of the plot.

- Now ac/dc load line meet @ Q point



Q

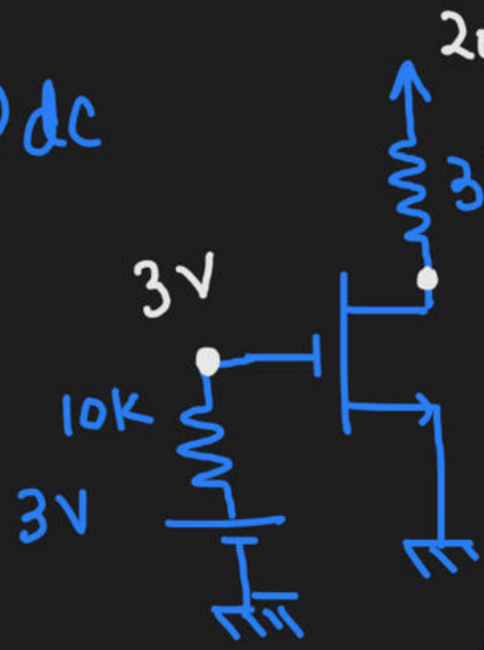


1) $V_{th} = 1V$,

$\mu_n C_{ox} \frac{W}{L} = 1mA/V^2$

1) Find $I_D = ?$

@dc



let device in Sat-

$V_{GS} = 3$

$V_{th} = 1$

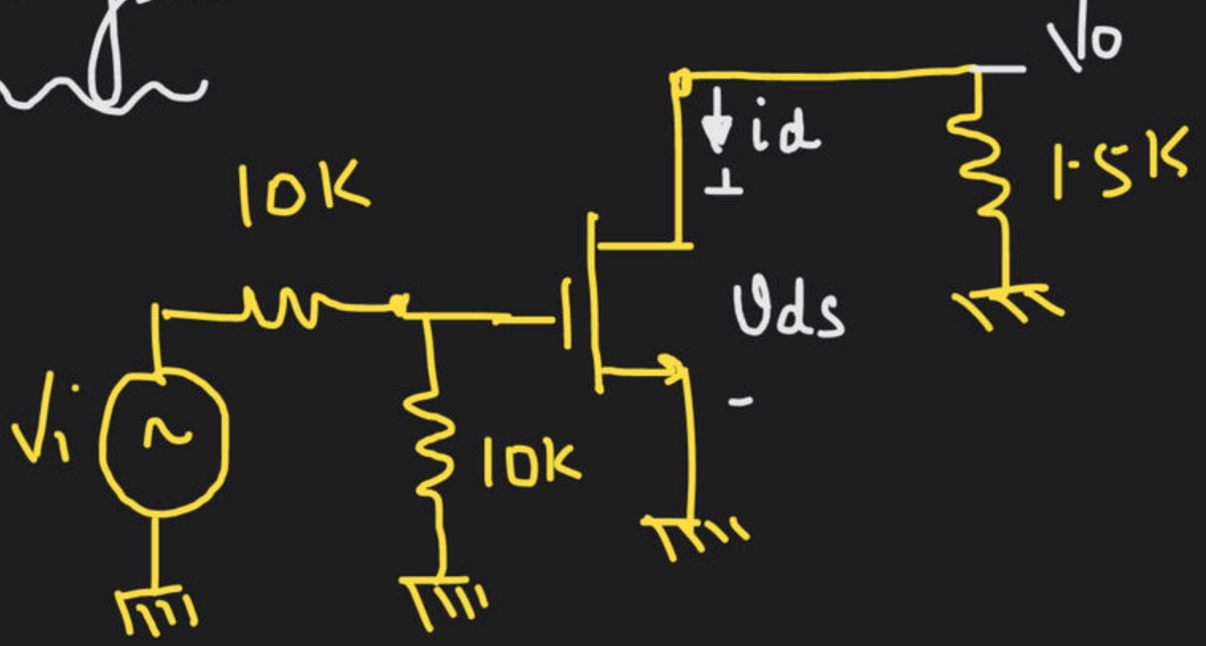
$I_D = 2mA$

$V_D = 14V.$

Bias point - ⇒ I_D, V_{DS}

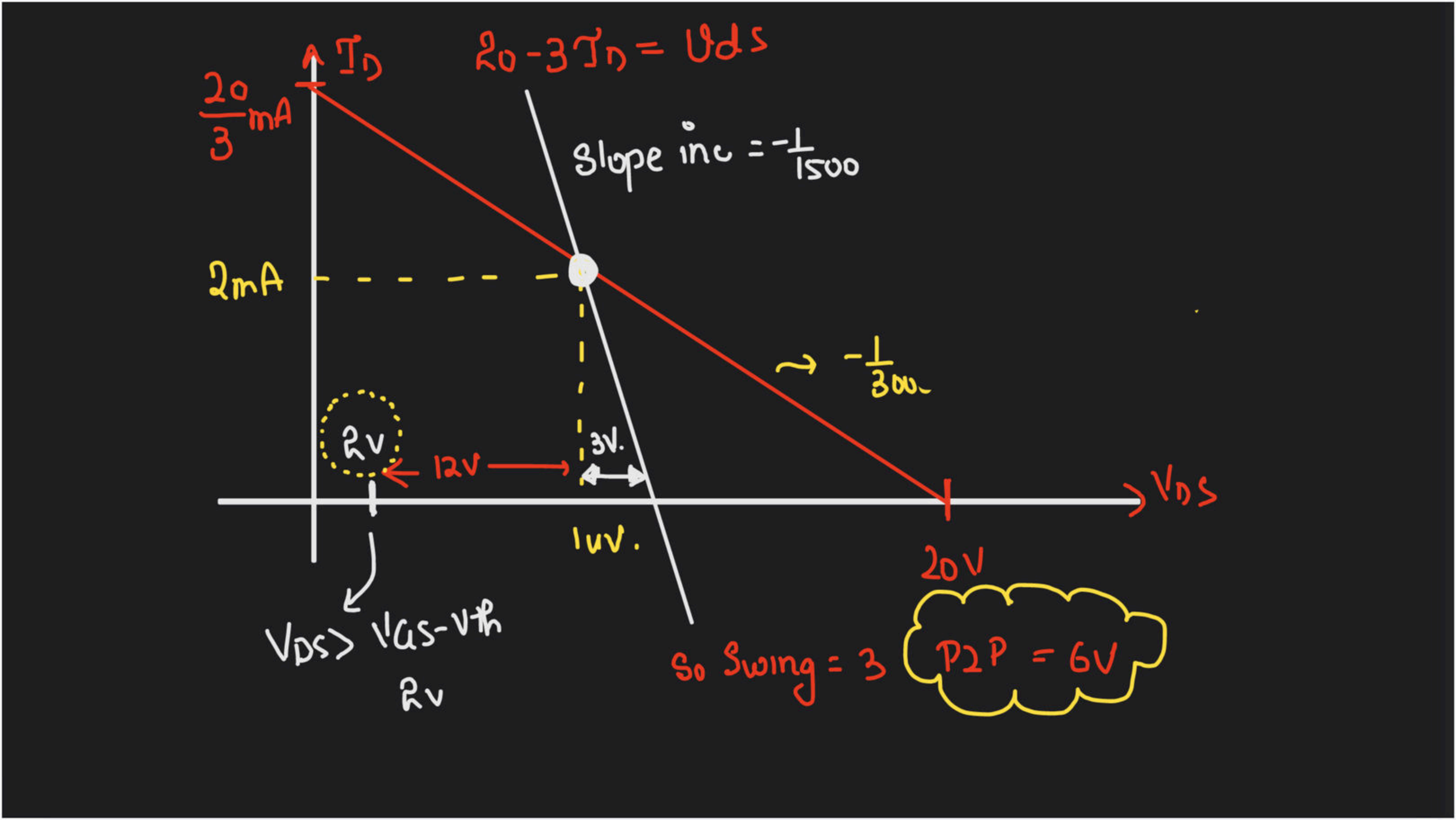
(2mA, 14V)

@ ac analysis

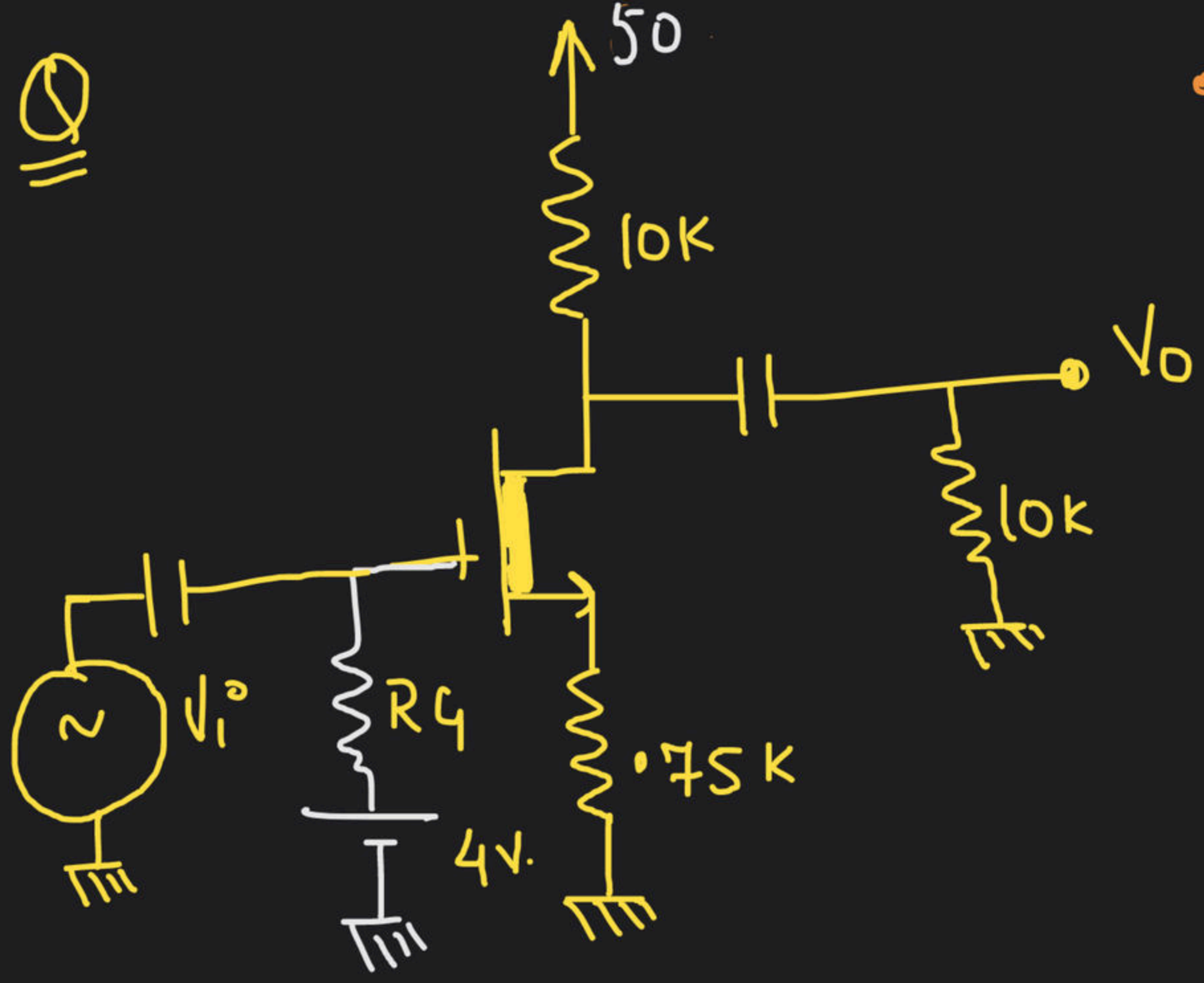


ac load line

$V_{ds} = -1.5K\, i_d$

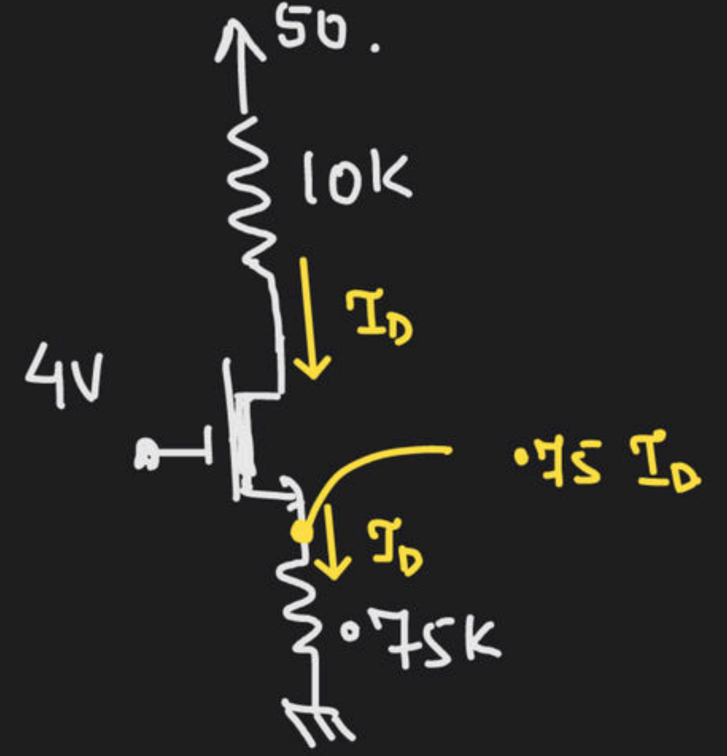

I_D
$20 - 3I_D = V_{DS}$
$\frac{20}{3}$ mA
Slope inc $= -\frac{1}{1500}$
2mA
$\rightsquigarrow -\frac{1}{300}$
2V
12V
3V.
V_{DS}
1uV.
20V
$V_{DS} > V_{GS} - V_{th}$
2V
So Swing = 3
P2P = 6V

Q



- $\mu_n C_{ox} \frac{W}{L} = .5 mA/V^2$
- $V_{th} = -1V$

Solve @ dc



@Sat

$$I_D = \frac{1}{2} \times 0.5 \left(4 - 0.75 I_D - (-1)\right)^2$$

$$4 I_D = \left(5 - 0.75 I_D\right)^2$$

$$4 I_D = 25 + 0.5625 I_D^2 - 7.5 I_D$$

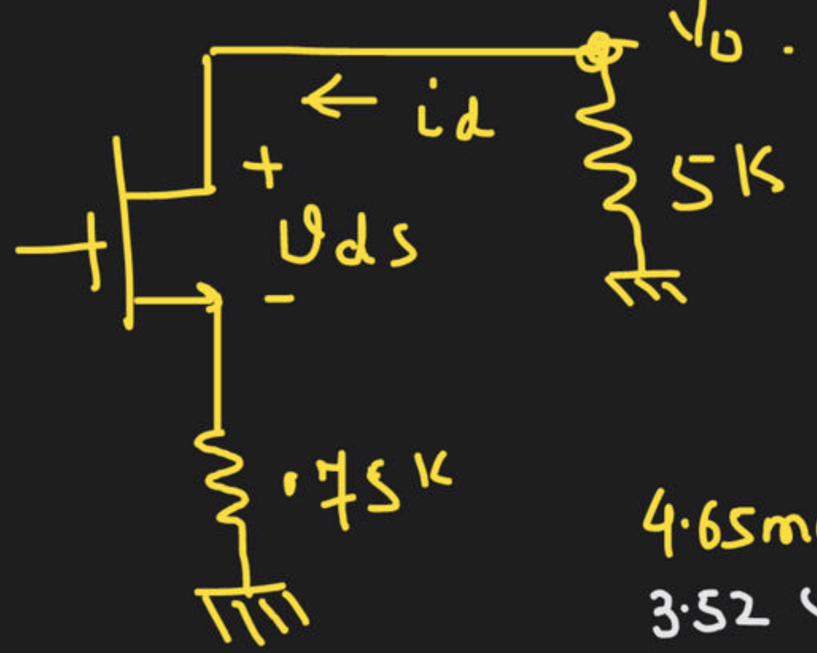
$$I_D = 2.47 \text{ mA}.$$

$$V_{DS} = 50 - (10.75 \times 2.47)$$

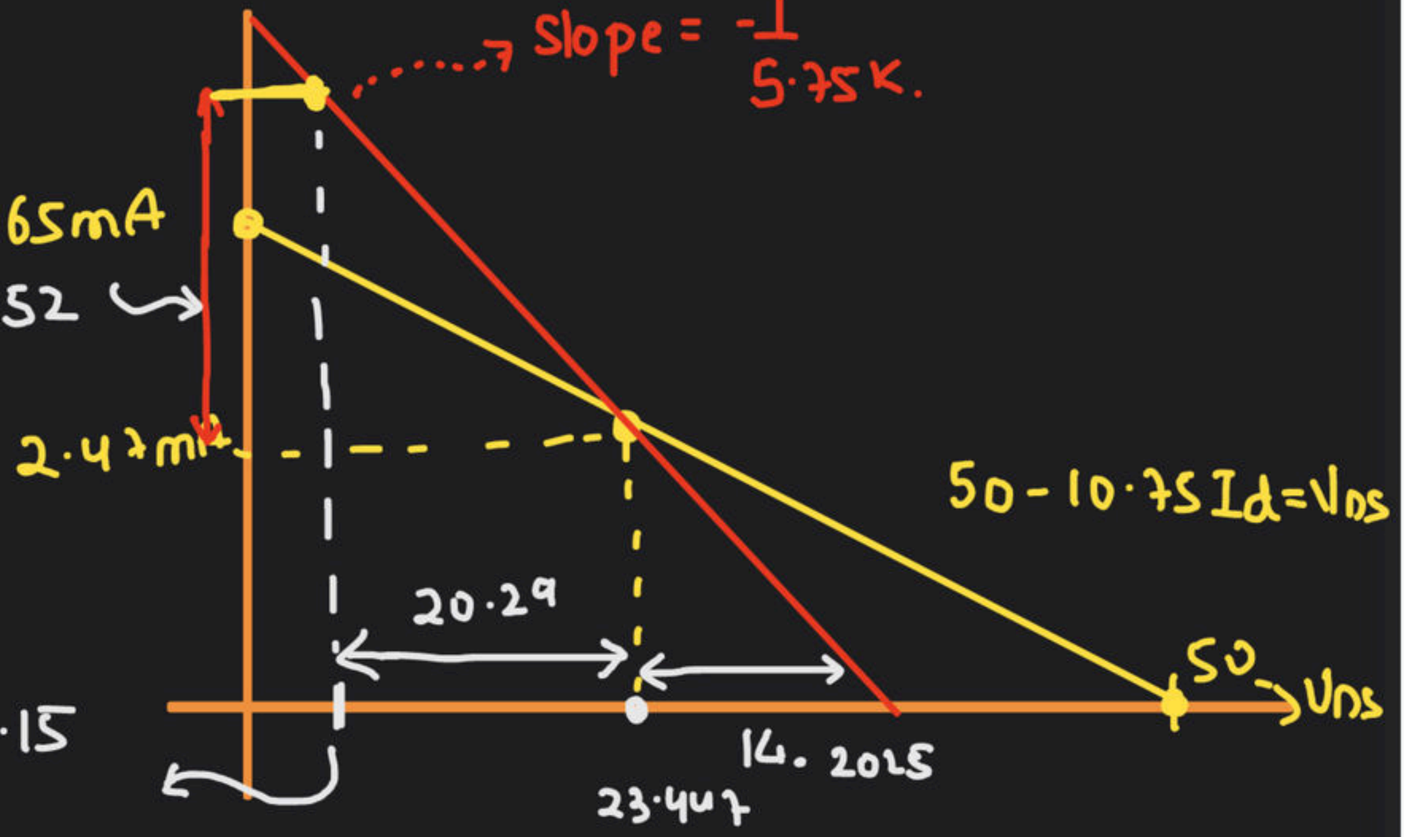
$$\underline{V_{DS}} = 23.447$$

$$V_{GS} = 4 - 0.75 I_D = 2.14$$

Now ckt @ dc



$V_{ds} = -5.75K \cdot i_d$



$(V_{GS} - V_{th}) = 3.15$

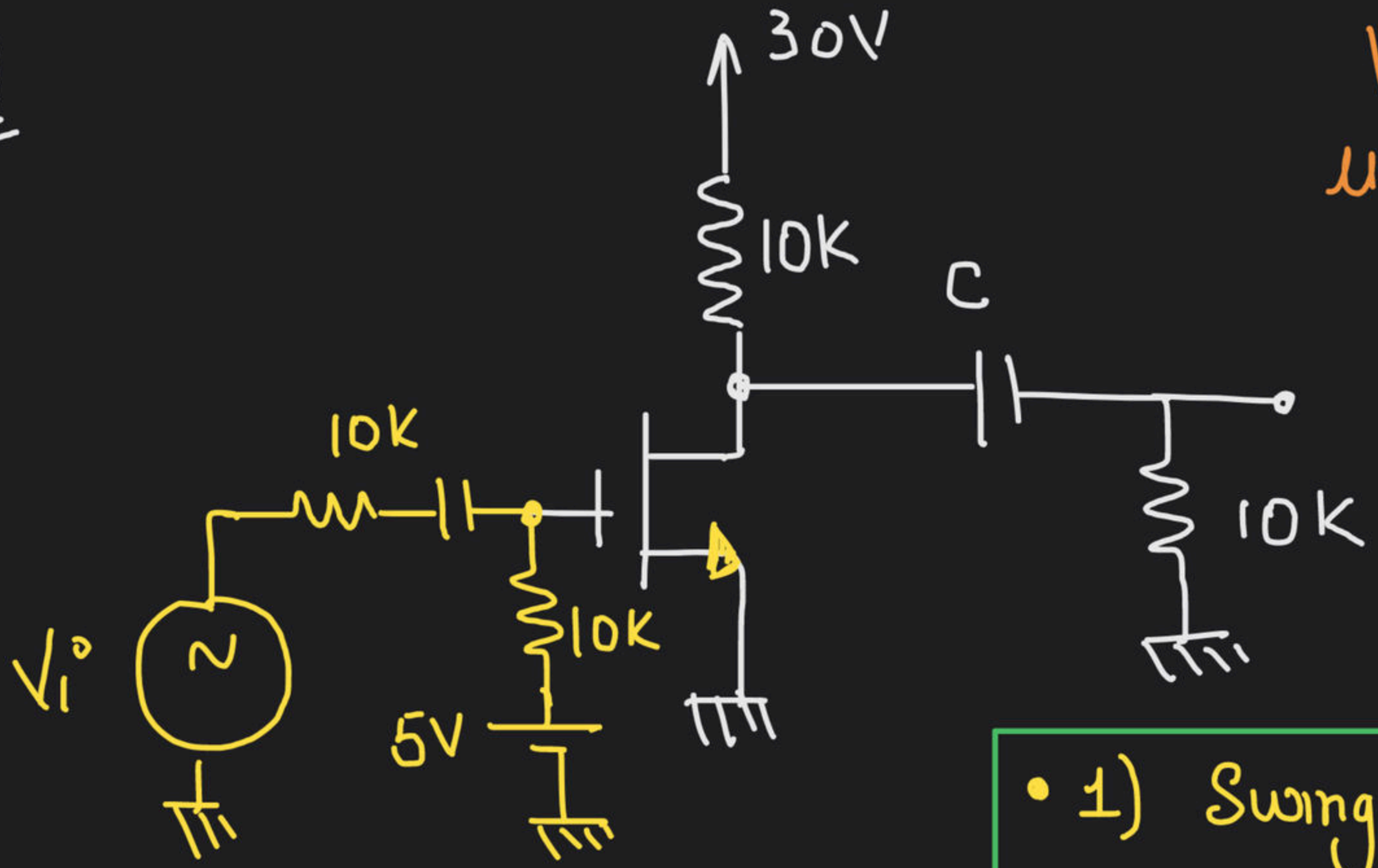
i_d swing 2.47 mA

$V_o = -5000\, i_d$

Swing @ V_o = +12.35

P2P = 24.7 V

Q



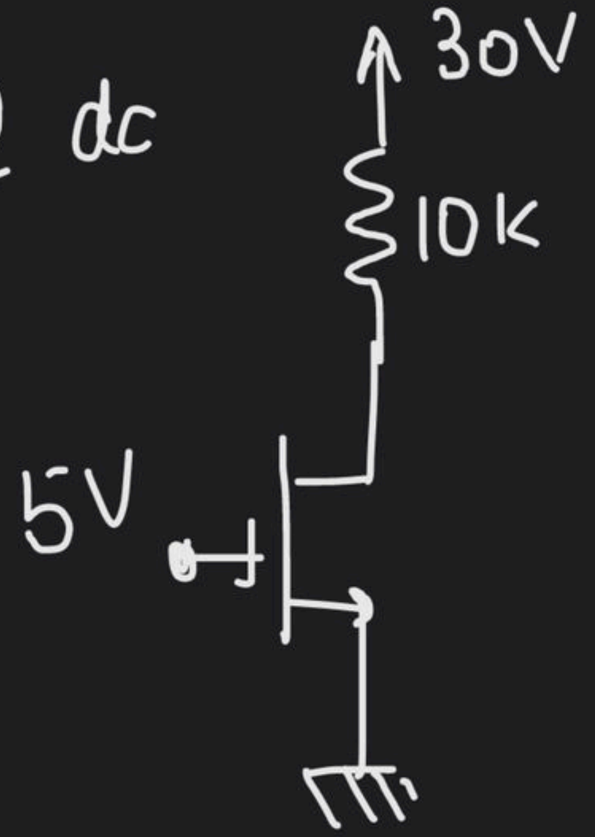
$V_{th} = 1V_g$

$\mu_n C_{ox} \frac{W}{L} = .2 mA/V^2$

- 1) Swing available @ 0/p

a) 14 ~~b) 8~~ c) 12 d) 10

@ dc

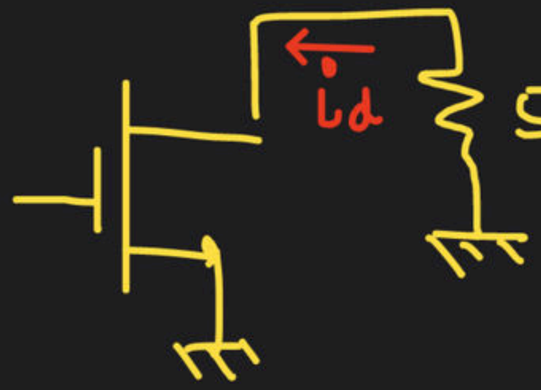


$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(5-1)^2$$

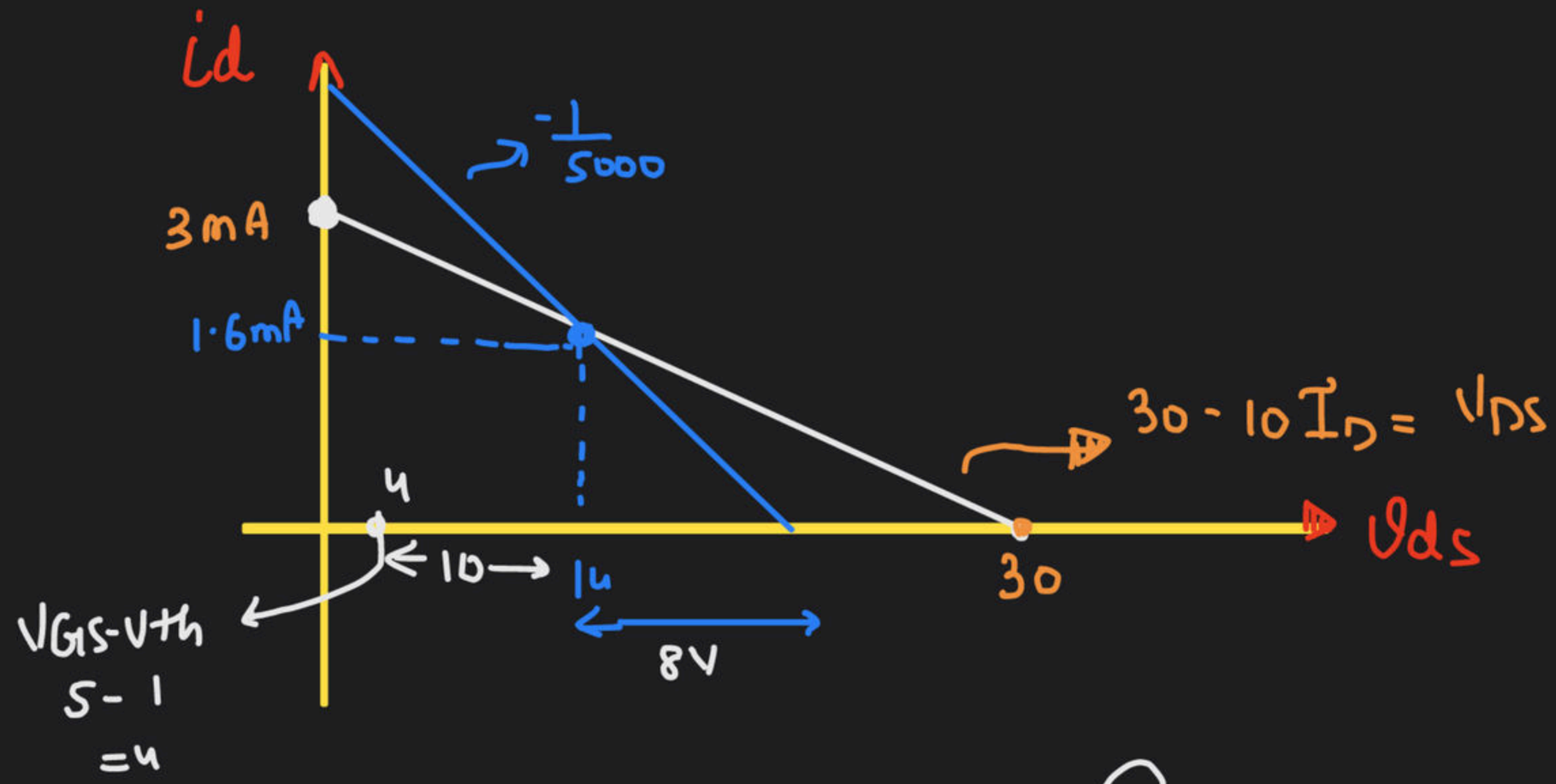
$$= \frac{1}{2} \times 0.2\,(4)^2 = 1.6\text{mA}$$

$$V_{DS} = 14\text{V}.$$

ac Analysis



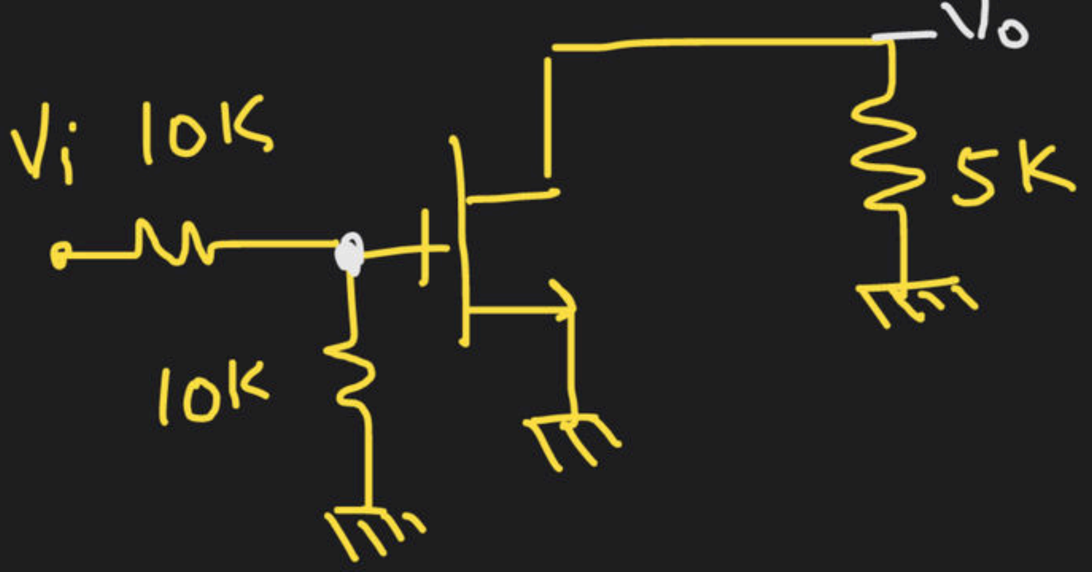
$$v_{ds} = -5000\, i_d$$



Q Find allowed Swing of input Signal =).

a) 8 b) 6 c) 4 d) 2

AC analysis ckt



$$g_m = \sqrt{2\mu_n C_{ox} \frac{W}{L} \times I_D}$$

$$= \sqrt{2 \times 1.6 \times 10^{-3} \times .2 \times 10^{-3}}$$

$$g_m = 8 \times 10^{-4}$$

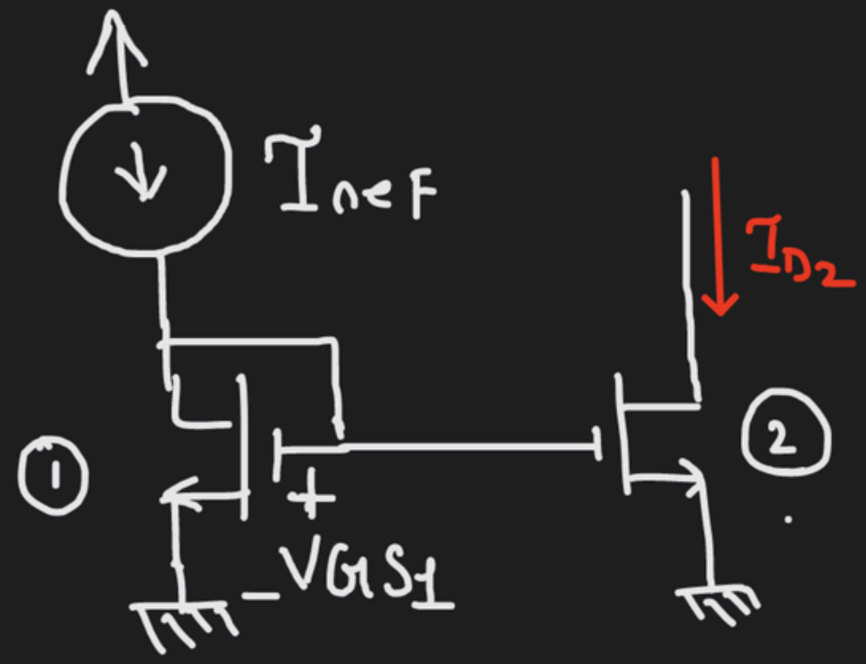
$$V_o = -g_m \vartheta_{gs} 5000$$

$$= -8 \times 10^{-4} \times \frac{1}{2} \times 5000 \ \vartheta_i$$

$$V_o = -2\vartheta_i$$

Topic Current mirror using Mosfet

The Basic Current mirror ⇒



- let Both are Identical devices

I_{REF} flow in drain of M_1 and V_{GS_1} voltage will be

developed

$$I_{D1} = I_{ref} = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{GS1} - V_{th})^2$$

$$\sqrt{\frac{I_{ref}}{K_n}} + V_{th} = V_{GS1}$$

Here $V_{GS1} = V_{GS2}$ thus

$$I_{D2} = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{GS2} - V_{th})^2$$ Since both device are same so $I_{ref} = I_{D2}$

assume that M_2 is in Sat mode

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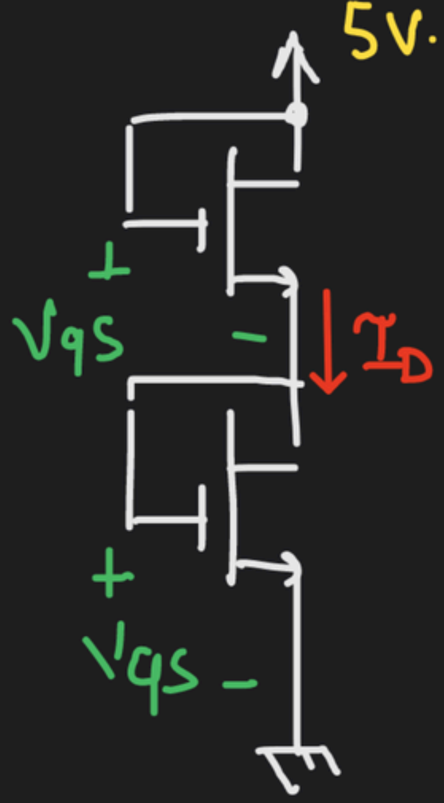
Q Find Current I_D



- $\mu_n C_{ox} \frac{W}{L}$ of both device = 1mA/V²

  $V_{th} = 1$

- Step1 Both in Sat

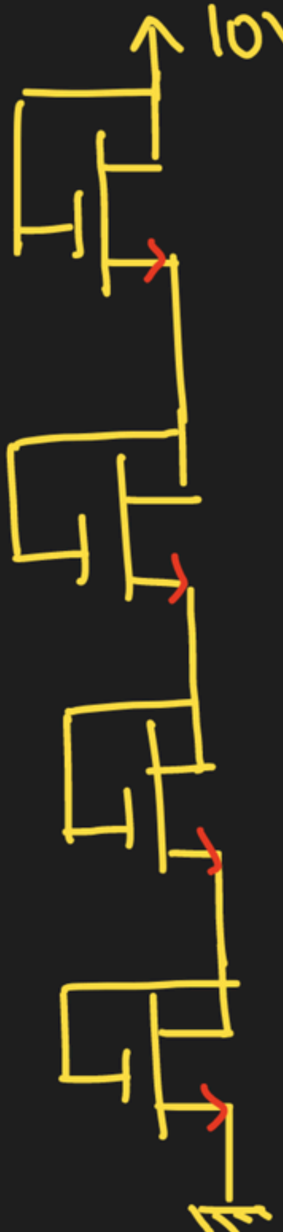
  identical device, V_{gs} same

$5 = 2V_{gs}$

$\underline{V_{gs} = 2.5}$

$I_D = \frac{1}{2} \times 1 \times (2.5 - 1)^2 = \underline{1.125mA}$

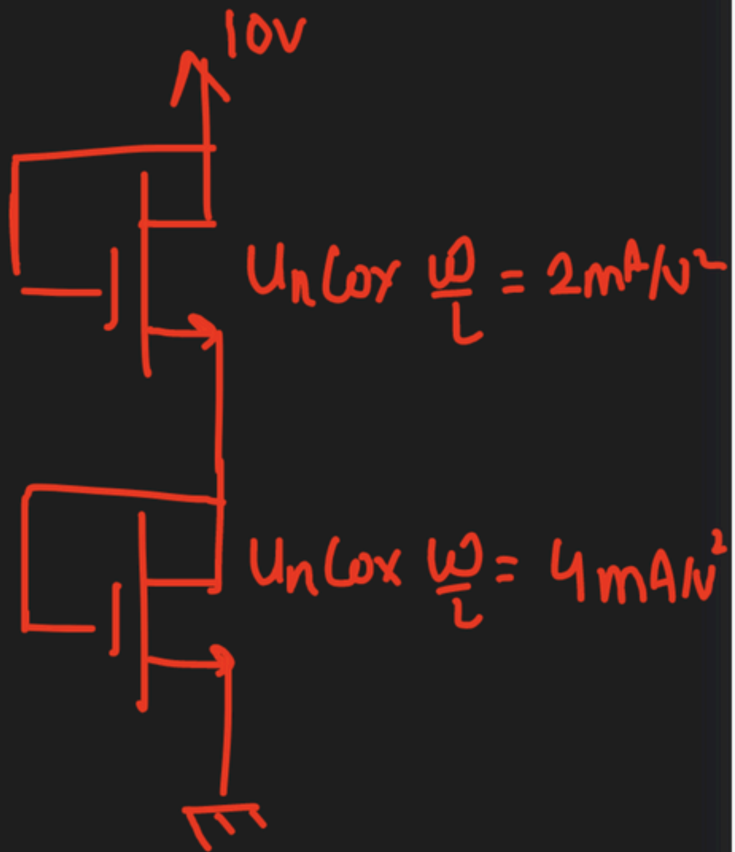
Q Find I_D



$\mu_n C_{ox} \frac{W}{L} = 1\,mA/V^2$

$V_{th} = 1V$

Q Find I_D



$V_{th} = 1V$ for both

. Find I_D.

Since device shd be in Sat-

$$V_{GD} < V_{th}$$

$$V_G - V_D < V_{th}$$

$$V_D > V_G - V_{th}$$

$$V_{DS} > V_{GS} - V_{th}$$

unacademy

▲ 1 • Asked by Anisha

Please help me with this doubt

Common Data For Q. 5 and 6 :

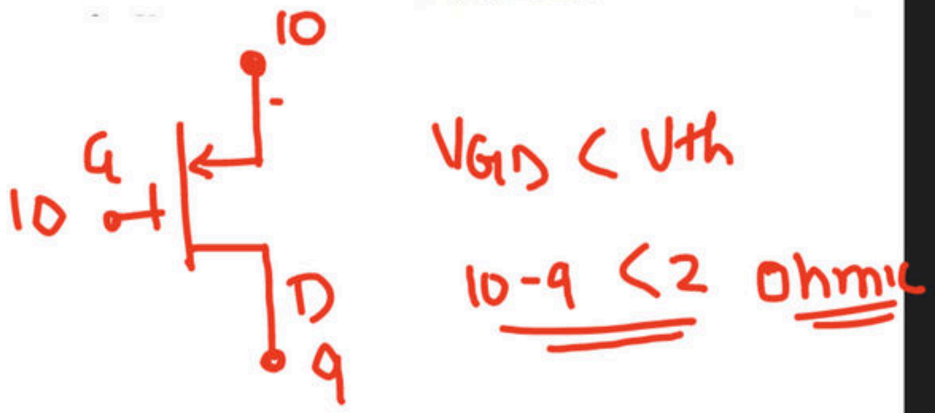
A p-channel depletion mode MOSFET has the following parameters

$$K_p = 0.5 \text{ mA/V}^2, V_{TH} = 2 \text{ V}$$

MCQ 4.1.5 If $V_{SG} = 0$, current I_D for $V_{SD} = 1$ V is

(A) 0 mA (B) 1.5 mA

(C) 2 mA (D) 0.5 mA



$V_{GD} < V_{th}$

$10 - 9 < 2$ ohmic

$y = x^2$

and $y = 5$

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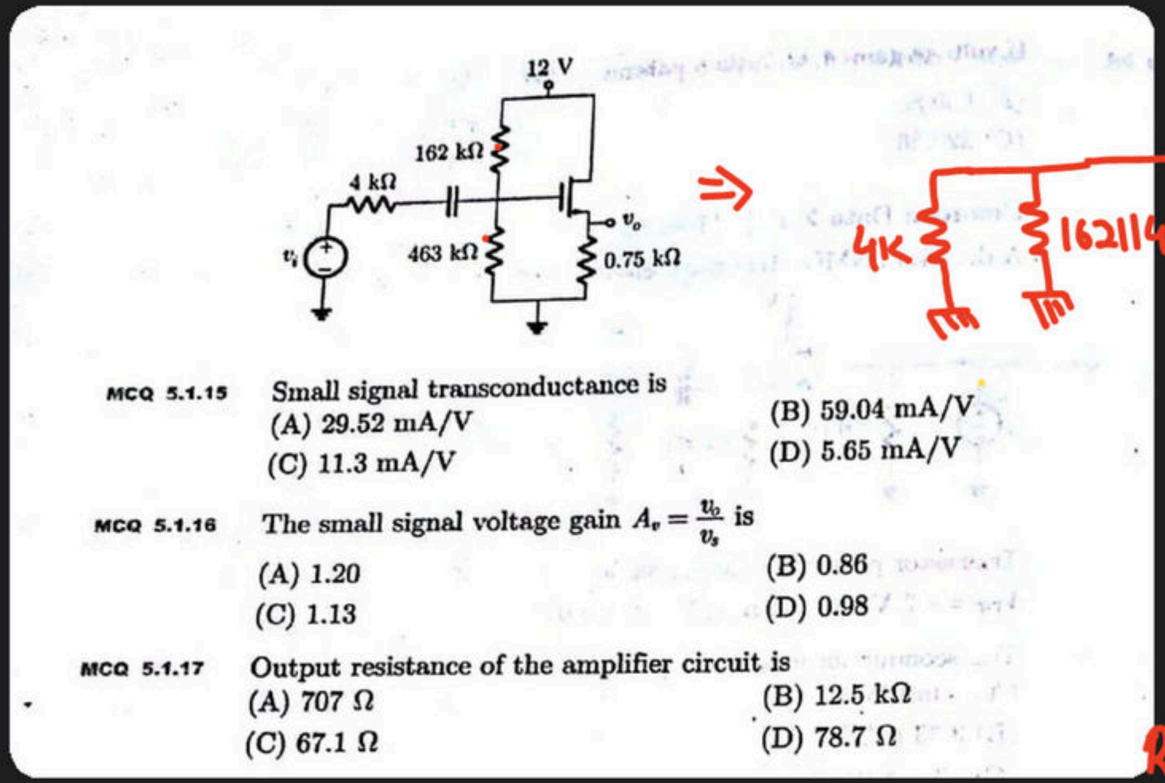
▲ 1 • Asked by Yuvraj

ouput resistance mai problem hai???



MCQ 5.1.15 Small signal transconductance is

(A) 29.52 mA/V (B) 59.04 mA/V

(C) 11.3 mA/V (D) 5.65 mA/V

MCQ 5.1.16 The small signal voltage gain $A_v = \frac{v_o}{v_s}$ is

(A) 1.20 (B) 0.86

(C) 1.13 (D) 0.98

MCQ 5.1.17 Output resistance of the amplifier circuit is

(A) 707 Ω (B) 12.5 kΩ

(C) 67.1 Ω (D) 78.7 Ω