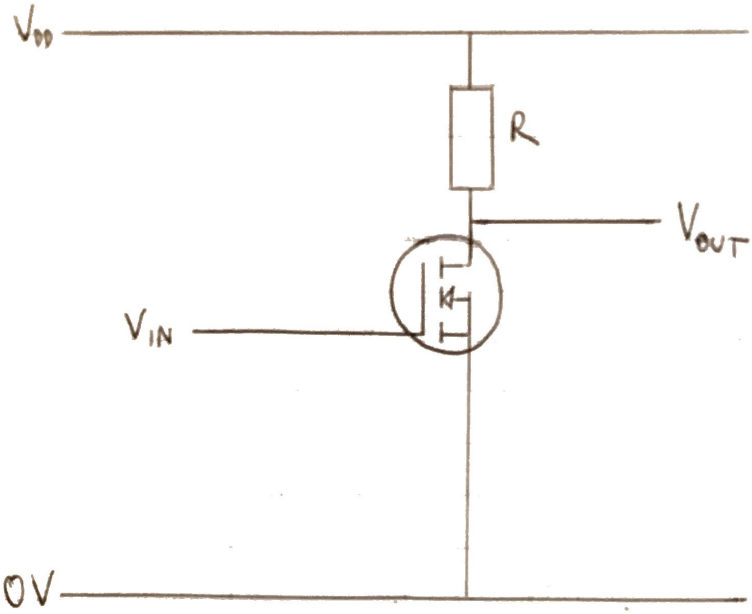
Morgan Saville

Digital Electronics 4

1.



2. Note: $V_{IN} = V_{GS}$

$V_{OUT} = V_{DS}$

The MOSFET has resistance R_{DS}

$$V_{DS} = V_{DD} \cdot \frac{R_{DS}}{R + R_{DS}}$$

$$R_{DS} = \frac{V_{DS}}{I_{DS}}$$

$$\therefore V_{DS} = V_{DD} \cdot \frac{V_{DS}}{RI_{DS} + V_{DS}}$$

Assuming $V_{DS} \neq 0$,

$$RI_{DS} + V_{DS} = V_{DD}$$

$$\therefore V_{DS} = V_{DD} - I_{DS} R$$

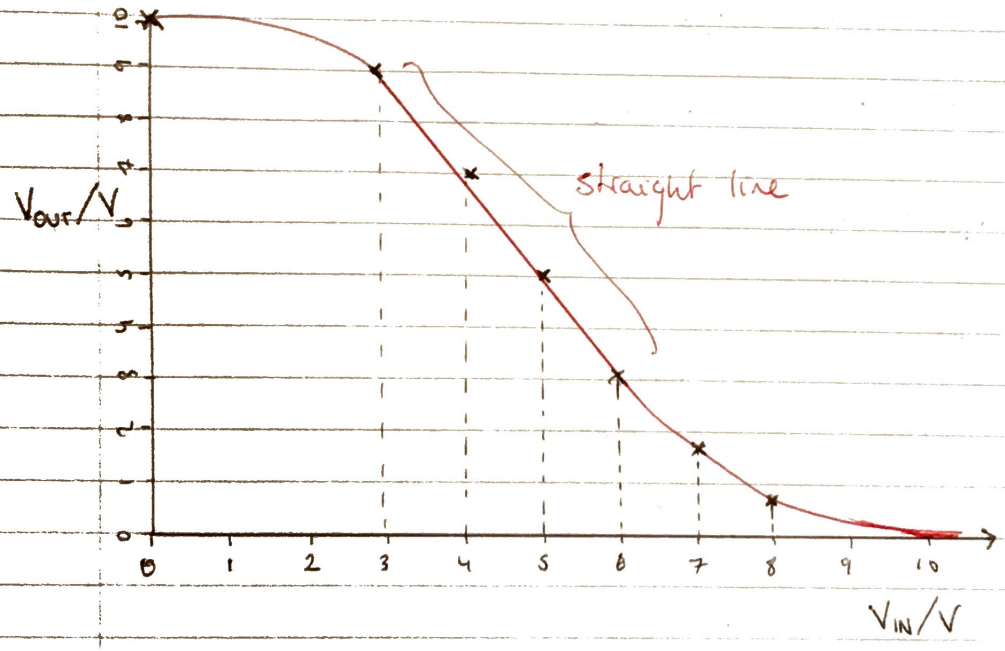
$$= 10V - 500\, I_{DS}\ \Omega$$

V_{IN}/V	I_{DS}/mA	V_{OUT}/V
0	0	10
3	2	9
4	6	7
5	10	5
6	14	3

For $V_{IN} \geq 7V$, the constant part of the characteristic no longer applies ~~the this case~~.

~~I_{DS} for $V_{IN} > 7V$, $I_{DS} = 9V_{DS}$~~

V_{IN}/V	I_{DS}/mAV^{-1}	V_{DS}	V_{OUT}/V
7	$9\,V_{DS}$	$10V - \frac{9}{2}V_{DS}$	$\frac{20}{11} \simeq 1.818$
8	$4\frac{1}{2}\,V_{DS}$	$10V - 4\frac{1}{4}V_{DS}$	$\frac{8}{9} \simeq 0.889$



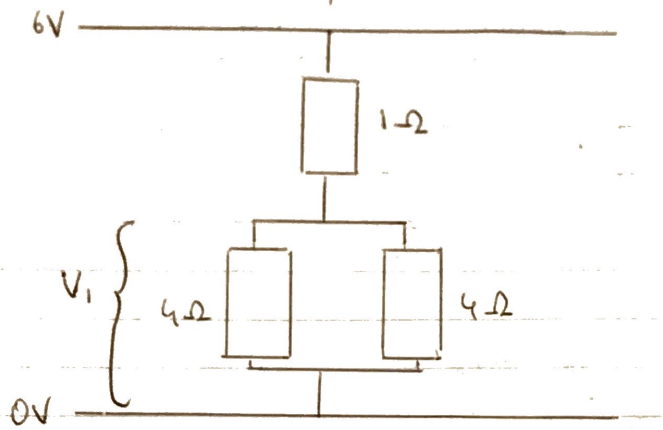
3. $V_{IN} = 8V$

$$V_{out} = V_{DS} = \tfrac{8}{9} V$$

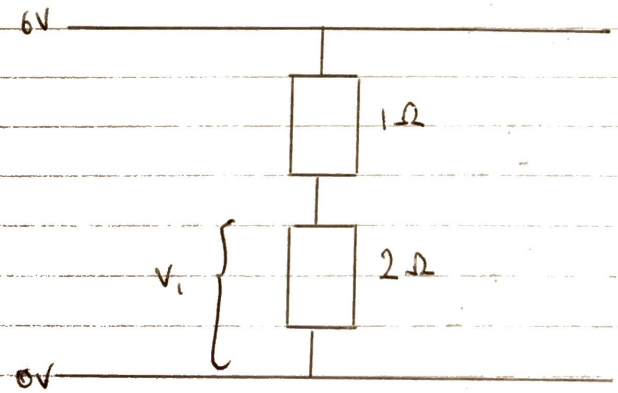
$$V_R = V_{DD} - V_{DS}$$
$$= (10 - \tfrac{8}{9}) V$$
$$= \tfrac{82}{9} V$$

$$P_R = \frac{V_R^2}{R} = \frac{(\frac{82}{9})^2}{500} W = \frac{1681}{10125} W \approx 166 \text{ mW}$$

4. The circuit is equivalent to:



and also to



a. $V = IR$

$\therefore 6V = I \cdot 3\Omega$

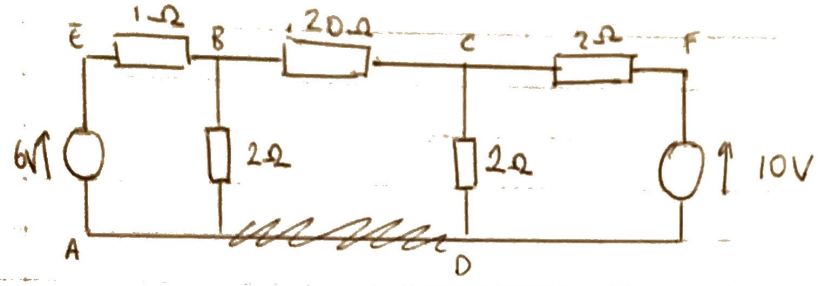
$\therefore I = 2A$

b. $V_1 = V \frac{R_2}{R_1 + R_2} = 6V \ \frac{2}{3} = 4V$

c. $2I = 2A$

$\therefore I = 1A$

5 Labelling more nodes:



- $I_{EB} + I_{AB} + I_{CB} = 0$

$\Rightarrow I_{EB} + I_{AB} = I_{BC}$ ①

- $I_{FC} + I_{DC} + I_{BC} = 0$

$\Rightarrow -I_{FC} - I_{DC} = I_{BC}$ ②

- $V_{AB} + V_{EB} + V_{BA} = 0$

$\rightarrow 6 = 2I_{AB} - I_{EB}$ ③

- $V_{DF} + V_{FC} + V_{CD} = 0$

$\Rightarrow 10 = 2I_{DC} - 2I_{FC}$

$\Rightarrow 5 = I_{DC} - I_{FC}$ ④

~~- $V_{AE} + V_{EB} + V_{BC} + V_{CF} + V_{FD} + V_{DC} + V_{CB} + V_{BA} = 0$~~

~~$\Rightarrow I_{EB} - 2I_{FC} + 2I_{DC} - 2I_{AB} = 4$~~ ⑤

From ③,

$I_{EB} = 2I_{AB} - 6$

From ④,

$I_{FC} = I_{DC} - 5$

Substituting into ~~(5)~~, ① and ②,

$3I_{AB} - 6 = -2I_{DC} + 5 = I_{BC}$

~~$3I_{AB} + 2I_{DC} = 11$~~

$I_{DC} = \frac{10}{4} = 5/2$

$\therefore I_{BC} = -5 + 5 = 0$

∴ there is no current flowing through the 2Ω resistor.

b. ~~I_{AB}~~ $I_{AB} = \frac{I_{BC} + 6}{3} = 2A$

$V_{AB} = I_{AB} \cdot 2\Omega = 4V$

$V_{AC} = V_{AB} + V_{BC} = 4V$

$V_{AD} = V_{AC} - V_{DC}$

$= 4 - 5/2 \cdot 2$

$= -1V$