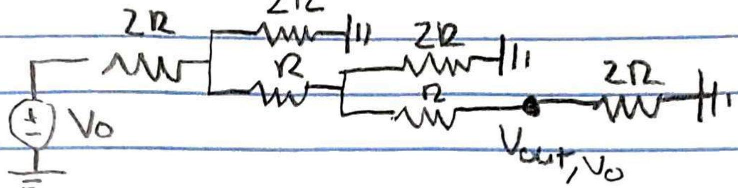
1. Filled out survey

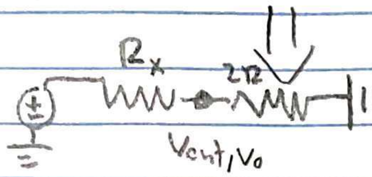
2. yes yes

3

(a) Use superposition:

(i) just $V_0$:




"voltage divider

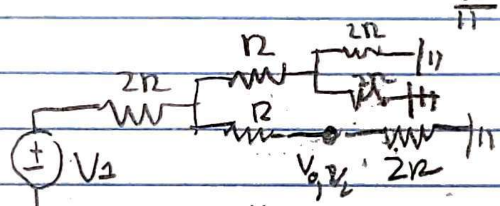
$$R_x = 2R + \left(\frac{2R \cdot \left(R + \frac{2R \cdot R}{2R + R}\right)}{2R + R + \frac{2R \cdot R}{2R+R}}\right)$$

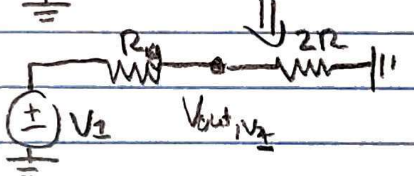
$$= 2R + \left(\frac{2R \cdot \left(R + \frac{2}{3}R\right)}{2R + R + \frac{2}{3}R}\right)$$

$$= 2R + \left(\frac{\frac{10}{3}R^2}{\frac{11}{3}R}\right)$$

$$= 32/11\, R \implies V_{out,V_0} = \frac{2R}{\frac{32}{11}R + 2R} V_0 = \frac{22}{54} V_0 = \frac{11}{27} V_0$$

(ii) just $V_1$



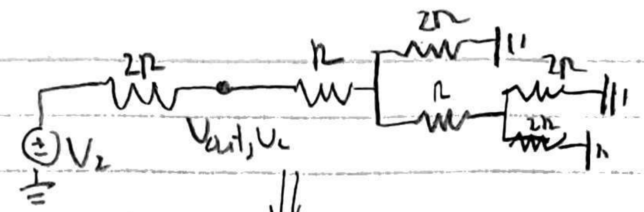

$$R_y = 2R + \left(\frac{\left(R + \frac{2R \cdot 2R}{2R + 2R}\right) \cdot R}{R + \frac{2R \cdot 2R}{2R + 2R} + R}\right)$$

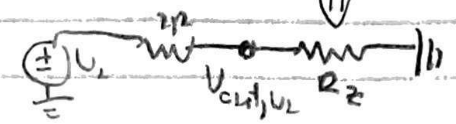
$$= 2R + \left(\frac{(R + R) \cdot R}{R + R + R}\right)$$

$$= 2R + \frac{2R^2}{3R}$$

$$= \frac{8}{3} R \implies V_{out,V_1} = \frac{2R}{\frac{8}{3}R + 2R} V_1 = \frac{3}{7} V_1$$

(iii) just $V_2$ :




$$R_Z = R + \left(\frac{2R\cdot\left(R+\frac{2R\cdot 2R}{2R+2R}\right)}{2R+\left(R+\frac{2R\cdot 2R}{2R\cdot 2R}\right)}\right)$$

$$= R + \left(\frac{2R\cdot(R+R)}{2R+(R+R)}\right)$$

$$= R + \left(\frac{4R^2}{4R}\right)$$

$$= R+R \Rightarrow \frac{2R}{2R+2R} = \frac{1}{2} \xRightarrow{x-1} -1V_2$$

$$V_{out} = \frac{11}{27}V_0 + \frac{3}{7}V_1 - V_2$$

$$\boxed{V_{out} = \frac{11}{27}\cdot b_0 V_{DD} + \frac{3}{7}\cdot b_1 V_{DD} - b_2 V_{DD}}$$

(b) $V_{out} = \frac{11}{27}V_{DD} + \frac{3}{7}V_{DD} = \boxed{\frac{20}{27}V_{DD}}$

(c) $V_{out} = \frac{11}{27}V_{DD} - V_{DD} = \boxed{\frac{-16}{27}V_{DD}}$

(d) $V_{out} = \frac{3}{7}V_{DD} - V_{DD} = \boxed{-\frac{4}{7}V_{DD}}$

(e) $V_{out} = \left(\frac{11}{27}+\frac{3}{7}-1\right)V_{DD} = \boxed{-\frac{7}{27}V_{DD}}$

(f) It uses combination of series and parallel resistors to turn binary digits into an analog voltage

(a) ~~$x^2 + y^2 = z^2 \Rightarrow z = \sqrt{x^2+y^2}$~~

~~$x^2 + y^2 = (x+jy)^2$~~

~~$x^2 + y^2 = x^2 + 2jxy + j^2y^2$~~

$|z| = \sqrt{z^2} = \sqrt{(x+jy)^2} = \sqrt{x^2+2jxy+j^2y^2} = \sqrt{x^2+2jxy-y^2}$

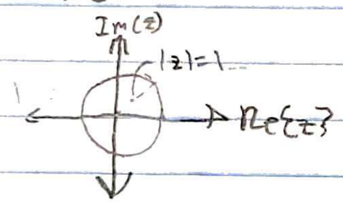
(b) $x = r\cos\theta \qquad y = r\sin\theta$

(c) $z = x + jy$

$= r\cos\theta + jr\sin\theta$

$= r(\cos\theta + j\sin\theta)$

$= re^{j\theta}$

(d) 


$z \in [1, -1, \sqrt{-1}, -\sqrt{-1}]$

(e) $z = x + jy$

$\bar{z} = z - 2jy$

$= re^{j\theta} - 2jr\sin\theta$

$= re^{j\theta} - 2(re^{j\theta}$

(f) $r^2 = z\bar{z}$

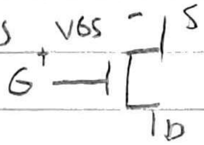
$= re^{+j\theta}re^{-j\theta}$

$= r^2 e^{j\theta - j\theta}$

$= r^2 e^0$

$= r^2$

(a) Nmos



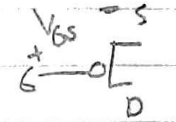

$V_{GS} = V_G - V_S = 1V - 2V = -1V \leq 0.5$

$\Downarrow$

"off"

equivalent circuit is B

(b) pmos



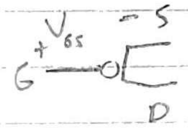

$V_{GS} = V_G - V_S = 0.4 - 2 = -1.6V \leq -0.6$

$\Downarrow$

"on"

equivalent circuit is B

(c) pmos

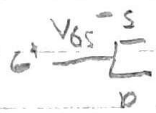



$V_{GS} = V_G - V_S = 0.7 - 2 = -1.3V \leq -0.6$

$\Downarrow$

"on"

nmos




$-1.3 < 0.5 \Rightarrow$ "off

equivalent circuit is C

6

(a) $\frac{\delta}{\delta t} x_d(t) = \frac{\delta}{\delta t}\left(x_0 e^{\alpha t}\right) = \alpha \cdot x_0 e^{\alpha t} = \alpha x_d(t)$

$x_d(0) = x_0 e^{\alpha \cdot 0} = x_0$

(b) $z(0) = \frac{y(0)}{e^{\alpha \cdot 0}} = \frac{x_0}{1} = x_0$

$\frac{\delta}{\delta t} z(t) = \frac{\delta}{\delta t}\left(\frac{y(t)}{e^{\alpha t}}\right) = \frac{e^{\alpha t} \cdot \alpha y(t) - y(t) \cdot \alpha e^{\alpha t}}{(e^{\alpha t})^2} = 0$

$z(0) = y(0) = x(0)$ and $y(0)$ won't change b/c $\frac{\delta}{\delta t} z(t) = 0$. It will always be equal to x for all value of t

8. nah

9. no sources, no-one, 5