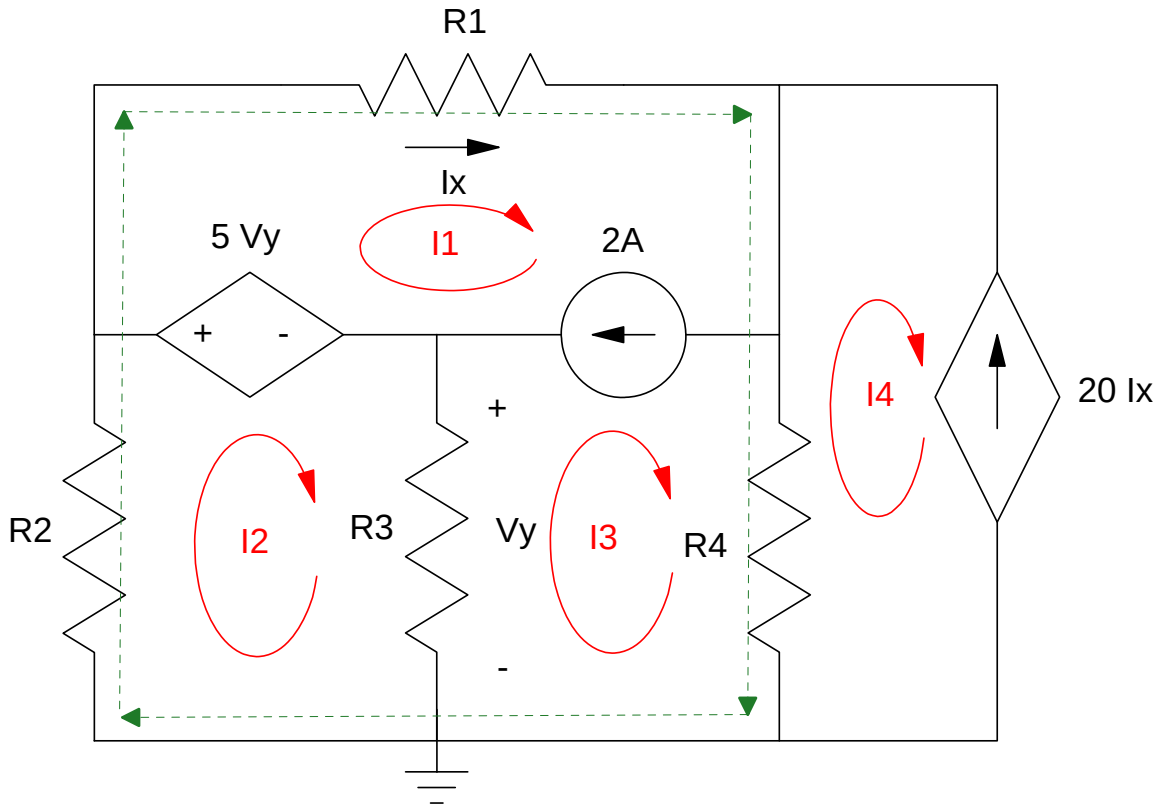
ECE 320 - Quiz #1 - Name _____

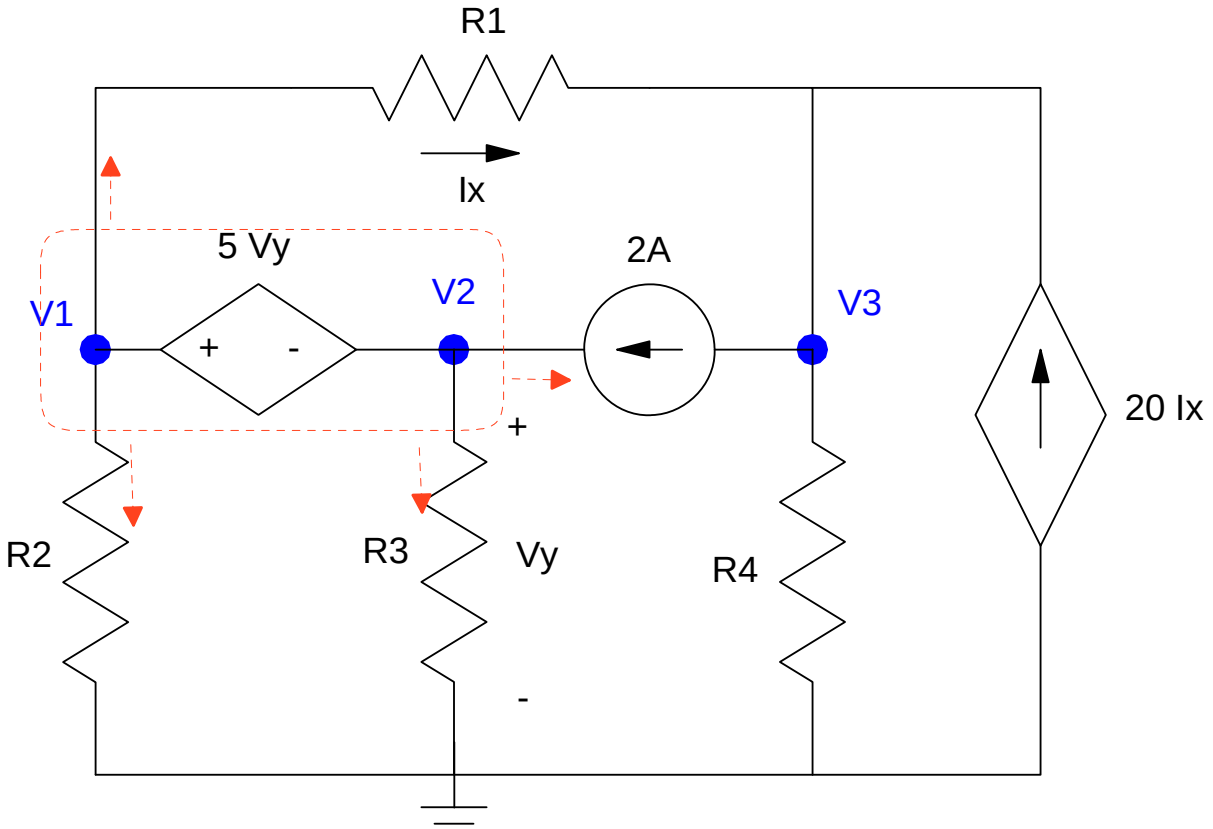
ECE 206 Review. January 19, 2017

1) Give N current loop equations to allow you to solve for the N unknown currents in this circuit



$I_x = I_1$
$V_y = R_3(I_2 - I_3)$
$I_1 - I_3 = 2$
$I_4 = -20I_x$
$R_2I_2 + 5V_y + R_3(I_2 - I_3) = 0$
$R_2I_2 + R_1I_1 + (I_3 - I_4)R_4 = 0$

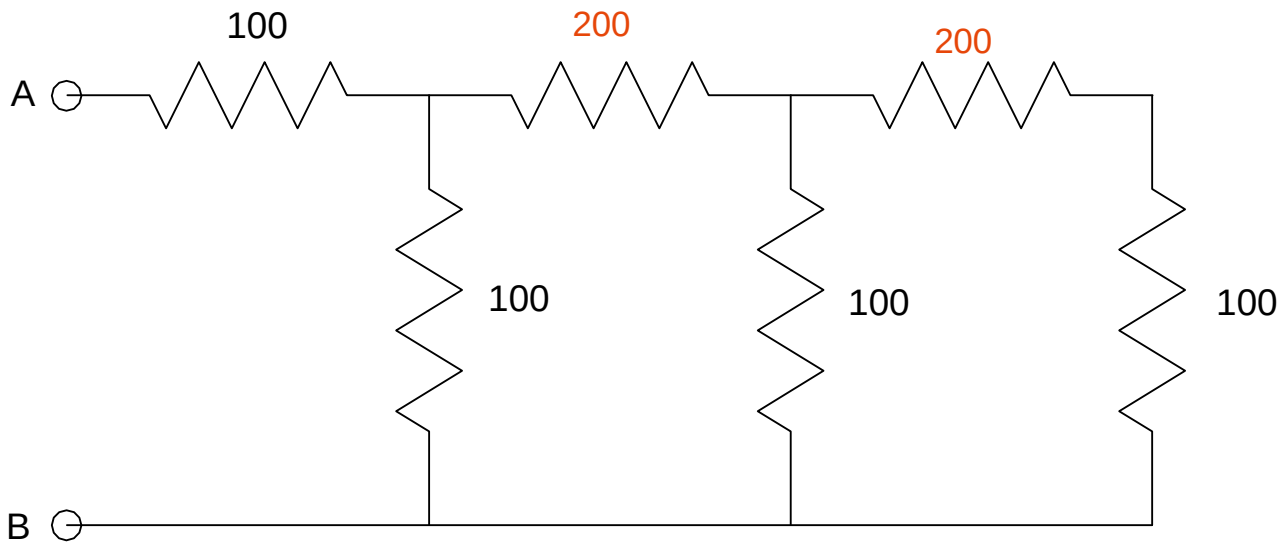
2) Give N voltage node equations to allow you to solve for the N unknown voltages in this circuit



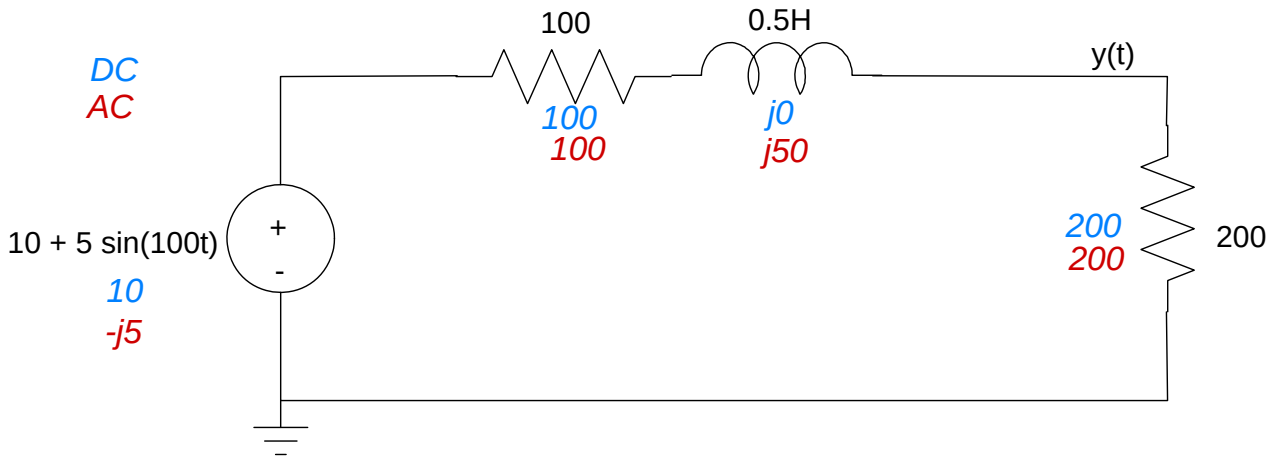
$I_x = \left(\frac{V_1 - V_3}{R_1}\right)$
$V_y = V_2$
$V_1 - V_2 = 5V_y$
$2 + \left(\frac{V_3}{R_4}\right) + \left(\frac{V_3 - V_1}{R_1}\right) - 20I_x = 0$
$\left(\frac{V_1}{R_2}\right) + \left(\frac{V_1 - V_3}{R_1}\right) + \left(\frac{V_2}{R_3}\right) - 2 = 0$

3) Find the resistance between A and B

R_{AB} = 173.3 Ohms



4) Find the voltage at Y



DC Analysis (blue)

$V_{in} = 10$

$\omega = 0$

$L \rightarrow j\omega L = 0$

$y = \left(\frac{200}{200+100}\right) 10$

$y = 6.667$

AC Analysis (red)

$V_{in} = 5\sin(100t) \rightarrow -j5$

$\omega = 100$

$L \rightarrow j\omega L = j50$

$y = \left(\frac{200}{200+100+j50}\right) \cdot (-j5)$

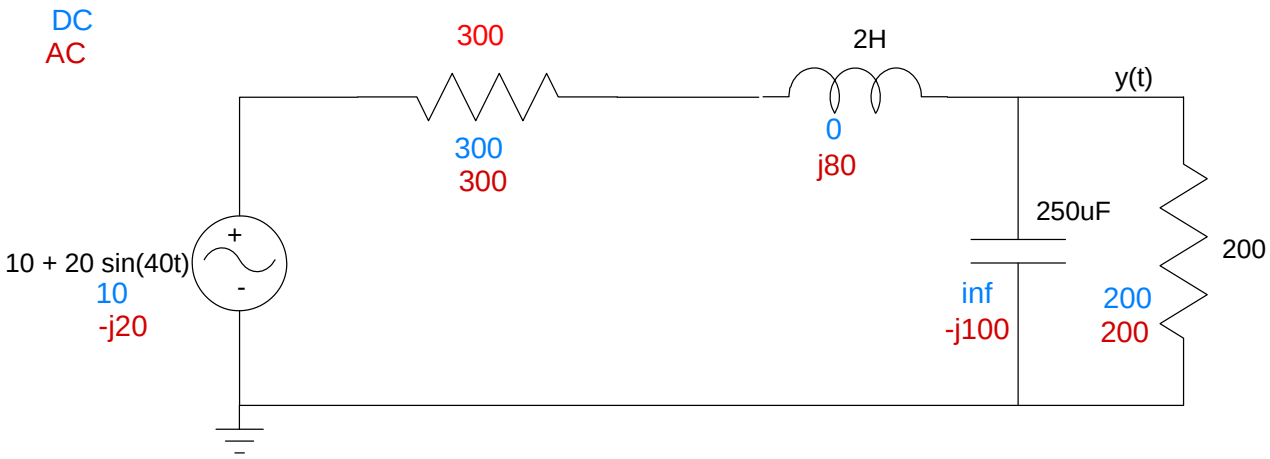
$y = 3.288\angle -99^0$

$y(t) = 3.288\cos(100t - 99^0)$

Total Answer = DC + AC

$$y(t) = 6.667 + 3.288\cos(100t - 99^0)$$

5) Find the voltage at Y



DC Analysis (blue)

$V_{in} = 10$

$\omega = 0$

$L \rightarrow j\omega L = 0$

$C \rightarrow \frac{1}{j\omega C} = \infty$

$200||\infty = 200$

$y = \left(\frac{200}{200+300}\right)10$

$y = 4$

AC Analysis (red)

$V_{in} = 20\sin(40t) \rightarrow -j20$

$\omega = 40$

$L \rightarrow j\omega L = j80$

$C \rightarrow \frac{1}{j\omega C} = -j100$

$200||-j100 = \left(\frac{1}{200} + \frac{1}{-j100}\right)^{-1} = 89.44\angle -63^0$

$y = \left(\frac{\left(89.44\angle -63^0\right)}{\left(89.44\angle -63^0\right)+(300+j80)}\right)\cdot(-j20)$

$y = 5.76\angle -153^0$

$y(t) = 5.76\cos(40t - 153^0)$

Total Answer: DC + AC

$$y(t) = 4 + 5.76\cos(40t - 153^0)$$

BONUS! How much coal do you have to burn in a year to keep everyone's cell phone charged in the U.S?
Assume

- 300 million people in the U.S. (300 million cell phones)
- It takes 8 Watt-hours of electricity to charge each cell phone each day (3.3V, 2.4mAh)
- 1 pound of coal produces 1 kWh of electricity

$$Energy = \left(8 \frac{\text{Watt-hours}}{\text{day}}\right)\left(365 \frac{\text{days}}{\text{year}}\right)(3,000,000 \text{ people})$$

$$= 876 \cdot 10^9 \ Watt \cdot hours$$

$$= 876 \cdot 10^6 \ kWh$$

$$\approx 876 \cdot 10^6 \text{ pounds of coal}$$

To put this in perspective, 876 million pounds of coal is

- 9km x 9km x 10m in size
- A train with 3,743 fully loaded coal-cars, which would be over 6km long

That coal would produce

- 3.2 billion pounds of CO_2
- Which has a volume of 742 million m^3
- Which is the volume of a cube which is 905m on a side

Just to keep our cell phones charged